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VIRGINIA GEOLOGICAL SURVEY 1922

UNIVERSITY OF VIRGINIA

THOMAS LEONARD WATSON, PH. D.

DIRECTOR

DEPARTMENT OF MINES

DIVISION OF MINERAL RESOURCES

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Bulletin No. XXIII

Manganese Deposits of Western Virginia

BY

G. W. STOSE AND H. D. MISER

PREPARED IN CO-OPERATION WITH THE
UNITED STATES GEOLOGICAL SURVEY

CHARLOTTESVILLE
UNIVERSITY OF VIRGINIA

1922



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LETTER OF TRANSMITTAL

VIRGINIA GEOLOGICAL SURVEY,

UNIVERSITY OF VIRGINIA,

CHARLOTTESVILLE, September 15, 1922.

*Governor E. Lee Trinkle, Chairman, and Members of the
State Geological Commission:*

GENTLEMEN: I have the honor to transmit to you herewith and to recommend for publication as Bulletin No. XXIII of the Virginia Geological Survey Series of Reports a manuscript and illustrations of a report entitled "Manganese Deposits of Western Virginia," by G. W. Stose and H. D. Miser.

This report, prepared in coöperation with the United States Geological Survey, treats of the manganese deposits of western Virginia, and is the second report to be published by the Virginia Geological Survey on that important mineral resource of the State west of the Blue Ridge. It gives a clear exposition of the nature and importance of the manganese deposits of an extensive belt which occupies the western side of the Appalachian Valley and extends from the northern to the southwestern part of the State. The commercial importance of this belt as a manganese producer was emphasized during the recent World War.

Bulletins Nos. XVII and XXIII complete the survey of the manganese deposits in Virginia west of the Blue Ridge—a region which thus far has contributed the major part of the State's production of manganese ores. To those who may be interested in the future mining developments of manganese ores in Virginia west of the Blue Ridge, Bulletins XVII and XXIII of the Virginia Geological Survey should prove to be of real value.

Respectfully submitted,

THOMAS L. WATSON,

Director and State Geologist.

MANGANESE DEPOSITS OF WESTERN VIRGINIA

BY G. W. STOSE AND H. D. MISER.

INTRODUCTION

Manganese deposits have been known to occur in the Valley of Virginia for many years, but until recently the worked deposits have been almost entirely restricted to the eastern side of the Valley adjacent to the Blue Ridge. Some manganese mining had, however, been done in Massanutten Mountain, Shenandoah County, and in the Paddy Run section of Frederick County as early as 1834. During the World war, due to the increased need of manganese ore in the steel industry and the scarcity of the ore caused by the cessation of imports to this country, search was made throughout the country for new deposits. In 1917 manganese ore was reported from other localities in western Virginia, and in that year mining was begun at several places, particularly in Giles and Bland counties, near Bluefield, W. Va., where considerable excitement was caused by the finding of comparatively large and fairly accessible deposits. Other deposits in the adjacent region to the southwest and northeast along this ore-bearing belt were later discovered and exploited.

The area described in this report covers the western part of Virginia, including all of the Appalachian Valley except its eastern margin adjacent to the Blue Ridge and Appalachian Mountains. The field work for this report was undertaken jointly by the Virginia Geological Survey and the U. S. Geological Survey, and was a continuation of the study of the manganese deposits of the southern Appalachian region in Virginia, Tennessee, and Georgia that had been begun earlier by the writers and others. A report on the deposits along the west foot of the Blue Ridge, Va., by F. J. Katz, D. F. Hewett, and the writers was published in 1919 as Bulletin XVII of the Virginia Geological Survey, a report on the deposits in eastern Tennessee by G. W. Stose and F. C. Schrader was published in 1918 in Volume 8 of the Resources of Tennessee, Geological Survey of Tennessee, and a report on the deposits in Georgia by J. D. P. Hull, Laurence LaForge, and W. R. Crane was published in 1919 as Bulletin 35 of the Geological Survey of Georgia.

A brief visit to Bland and Giles counties was made in June, 1918, by E. G. Spillsbury, representing the Bureau of Mines, and G. W. Stose, of the U. S. Geological Survey, in response to the many inquiries from that area caused by the successful mining operations of R. B. Miller, the pioneer in the mining of manganese ore in these counties. This was followed by an examination of most of the reported deposits and occurrences of manganese ore in western Virginia by G. W. Stose and H. D. Miser, of the U. S. Geological Survey, in August and September, 1918. The large area covered in this short time precluded as detailed an examination as might be desired of some of the deposits, but in a later visit in July, 1920, Mr. Miser supplemented this work by planetable surveys of some of the most important mines and examined some openings made since the former visit. The maps prepared by Mr. Miser and maps of the Powells Fort mine in the Massanutten Mountains by T. K. Harnsberger, of the Virginia Geological Survey, are incorporated in this report. During the study of the deposits in Tazewell, Bland, and Giles counties the writers were accompanied for a few days by T. L. Watson, State Geologist, and during the study of the deposits in Giles, Bland, Craig, Bath, Alleghany, Shenandoah, and Frederick counties, they were accompanied for several days by E. F. Burchard, of the U. S. Geological Survey. To these men the writers are indebted for advice during the field and office work. Several deposits of manganese ore in Russell, Bath, Alleghany, and Botetourt counties, not visited by the writers, were visited late in 1918 by F. C. Schrader, of the U. S. Geological Survey, and the results of his studies are incorporated in this report.

E. O. Ulrich, of the U. S. Geological Survey, has studied the fossil collections that were obtained by the writers and has given helpful advice regarding the age and correlation of the rock formations with which the manganese ores are associated. Acknowledgment is also due to the residents of the region for their uniformly courteous treatment and to the mine operators and other interested persons for information furnished. Among those to whom special acknowledgment is due are Ottomar Stange, of Washington, D. C., (formerly of Pittsburgh, Pa.); R. B. Miller, of Bluefield, W. Va.; W. H. Wyand, of Hagerstown, Md.; Chas. F. Nelson, of Strasburg, Va.; J. Carson Adkerson, of Woodstock, Va.; and Alexander Fleming, of the Kaylor-Fleming Manganese Co., of Zepp, Va.

As the discovery of most of the manganese deposits in western Virginia was made within the last few years and as only a comparatively small quantity of manganese ore was produced by this part of the State prior to

1917, there have been few reports published on the subject. These are listed below but none of them contain more than brief descriptions of the deposits.

BOYD, C. R., Resources of southwest Virginia: pp. 147-148, 164, and 178, John Wiley & Sons, 1881.

Describes briefly a deposit of manganese ore on Flat Top Mountain near the line between Giles and Bland counties and gives an analysis of the ore. The deposit described by him is apparently the same as that at the Stange mine. The occurrence of manganese ore at several other places in Giles, Bland, and Tazewell counties is mentioned.

WEEKS, J. D., U. S. Geological Survey Mineral Resources of the United States: pp. 323-328, 1886.

Deposits of manganese ore in Frederick, Shenandoah, and other counties are briefly described and analyses are given. The fullest descriptions are those of the Mineral Ridge (Paddy Mills), Capola Mountain, and Powells Fort mines.

PENROSE, R. A. F., JR., Manganese—its uses, ores, and deposits: Arkansas Geol. Survey Ann. Rept. for 1890, vol. 1, pp. 408-409, 1891.

Deposits of manganese ore at the Mineral Ridge (Paddy Mills), Capola Mountain, and Powells Fort mines are very briefly treated.

SPENCER, A. C., The geology of Massanutten Mountain in Virginia: Private publication, Washington, D. C., p. 12, 1897.

A short description of the Powells Fort mine is given.

WATSON, T. L., Mineral Resources of Virginia: pp. 252-255, The Virginia Jamestown Exposition Commission, Lynchburg, Va., 1907.

The Mineral Ridge (Paddy Mills), Capola Mountain, and Powells Fort mines are briefly described and five analyses of manganese ore from Gap Mountain in Craig County are given.

HARDER, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, pp. 66-68, 1910.

The Mineral Ridge (Paddy Mills), Capola Mountain, and Powells Fort (Baltimore) mines and a few small mines on Massanutten Mountain are briefly described. The descriptions of the mines on Massanutten Mountain were taken from unpublished notes by R. J. Holden.

ANONYMOUS, New manganese district in Virginia: Eng. and Min. Jour., vol. 104, No. 23, p. 990, Dec. 8, 1917.

A short discussion of the manganese ore deposits in the Bluefield district.

HANEY, MARSHALL, Manganese development in Virginia: Eng. and Min. Jour., vol. 106, No. 16, p. 697, Oct. 19, 1918.

Describes the Mineral Ridge (Paddys Run) mine.

WATSON, T. L., and WHERRY, E. T., Pyrolusite from Virginia: Wash. Acad. Sci. Jour., vol. 8., No. 16, pp. 550-560, 1918.

The physical, chemical, optical, and crystallographic properties of the pyrolusite from the Powells Fort mine are described and Watson concludes that this mineral has not been derived from manganite but is primary.

STOSE, G. W., Manganese deposits of the Appalachian Valley of Virginia and Tennessee (abstract): Wash. Acad. Sci. Jour., vol. 9, pp. 383-384, 1919.

Presents briefly general geologic features of and conclusions regarding the deposits, including those of western Virginia.

STOSE, G. W., Manganese ores of the Southern States: Eng. and Min. Jour., vol. 110, No. 6, pp. 256-262, 1920.

Presents rather fully general geologic features of and conclusions regarding the deposits, including those of western Virginia.

HARDER, E. C., and HEWETT, D. F., Recent studies of domestic manganese deposits: Amer. Inst. Min. and Met. Eng., Trans., vol. 53, pp. 3-50, 1920.

The ore-forming minerals, stratigraphic relations, genesis, production, composition, and reserves of the manganese ores of the United States, including Virginia, are discussed.

The geology of the areas in which the manganese deposits occur is described in some of the above reports. The geologic folios of the U. S. Geological Survey treating of parts of western Virginia were great help to the present writers in the study of the relation of the manganese deposits to the rock formations and to the structure of the rocks. These folios as well as some manuscript maps that were of assistance to the writers are as follows:

DARTON, N. H., U. S. Geological Survey Folio No. 14, Staunton; No. 32, Franklin; No. 61, Monterey.

CAMPBELL, M. R., U. S. Geological Survey Folio No. 12, Estillville; No. 26, Pocahontas; No. 44, Tazewell; No. 59, Bristol; Dublin quadrangle (manuscript map).

STOSE, G. W., U. S. Geological Survey, Abingdon quadrangle (manuscript map).

CAMPBELL, H. D., Lexington and Natural Bridge quadrangles (manuscript maps).

WATSON, THOMAS L., A Geological Map of Virginia, 1916.

GEOGRAPHY¹

The western part of Virginia, herein described, is comprised of an open flat-bottomed fertile valley and a parallel belt of high linear mountains and narrow valleys. These form part of the Appalachian Valley province, which is limited on the west by the Appalachian Plateaus, the eastern escarpment of which lies several miles northwest of the Virginia State boundary throughout most of its length but enters the southwestern part of the State.

APPALACHIAN VALLEY PROVINCE.

The Appalachian Valley province is divided lengthwise into two distinct parts, an eastern part which is a flat-bottomed valley, practically continuous along the whole length of the province and known as the Great Valley, and a western part made up of long narrow nearly parallel mountains that trend northeastward separated by narrow parallel valleys known as the Appalachian Valley Ridges. The eastern division in Virginia is generally referred to as the Valley of Virginia, but its various parts have been given local names. (See fig. 1.)

Valley of Virginia.

The Valley of Virginia extends in a general southwesterly direction for over 300 miles from the north boundary to the south boundary of the State, bending to west-southwest in its southerly portion. Although it is occupied by parts of several large drainage systems—the Shenandoah, James, Roanoke, New, and Holston rivers—and is in places notably dissected by these rivers and their tributaries, and, although the floor of its several parts stands at various altitudes between 500 feet and 2,500 feet above sea-level, it is, nevertheless, when examined in a broad way, seen to be a single, generally broad flat-bottomed valley everywhere several hundred feet, and in places 2,000 to 3,000 feet, below the summits of the Blue Ridge on the east and the Valley Ridges on the west. (See Pl. III.) In the following statements references to the valley floor should be understood to apply not to the narrow bottoms adjacent to the principal streams and their tributaries, but to the broad lowland between the streams into which the

¹ Written by G. W. Stose.

stream channels are cut. There are many local irregularities in the width of the valley due to spurs of the bordering mountains projecting into the valley, and in places the bounding mountains come so close together that the valley is nearly closed. There are in places also a few high mountain ridges that lie out in the valley parallel to the bordering mountains and divide it in two lengthwise.

The northern part of the Valley of Virginia is drained by Shenandoah River. At the Maryland State line it is 20 miles wide and its floor is relatively even and little dissected except near the large streams. Its altitude



Fig. 1.—Map of Virginia showing subdivisions of the Appalachian Valley province and the adjacent provinces. The Appalachian Valley province is shaded, diagonal lines being used for the Valley Ridges and horizontal lines for the Valley of Virginia, to the six parts of which the following names are given: Shenandoah, Fincastle, Salem, Dublin, Abingdon, and Powell.

here is between 500 and 600 feet, but it rises gradually southwestward. It has approximately the same width to the vicinity of Strasburg and Riverton, at the forks of Shenandoah River, beyond which the valley is divided lengthwise by Massanutten Mountain, a bold, high mountain ridge 45 miles long. North Fork of Shenandoah River drains the part northwest of the mountain and South Fork the part to the southeast. The valley southeast of Massanutten Mountain has an average width of about 5 miles, expanding to 6 or 8 miles in width near Luray and at Elkton and locally narrowing to 3 miles in width near Compton and south of Alma. The floor of this eastern part of the valley rises from about 700 feet in altitude at its

north end to 1,200 feet at its south end. The valley northwest of Massanutten Mountain has a general width of 6 to 10 miles, and its floor rises from about 800 feet altitude near Strasburg to about 1,500 feet at Harrisonburg. Beyond the southwest end of Massanutten Mountain the valley is again 20 miles wide, but narrows to about 14 miles near Greenville. This wider part of the valley is drained by North, Middle, and South rivers, which coalesce to form South Fork of Shenandoah River. Its floor rises southwestward from between 1,200 and 1,500 feet to 1,800 and 2,000 feet altitude near Lofton and Middlebrook on the Shenandoah-James divide, the higher levels prevailing on the northwest side of the valley.

The open valley continues with a width of 12 to 15 miles southwestward beyond the divide for 25 miles, this part of the valley being drained by the North Fork of James River and its tributaries. Its floor slopes southwestward from the 1,800 to 2,000 foot divide to about 1,200 feet in the vicinity of Lexington, but in places the streams are intrenched as much as 300 feet below the general level of the valley floor. Southwest of Lexington the valley narrows rapidly, and at Buchanan, about 20 miles distant, it is constricted to a width of $11\frac{1}{2}$ miles by Purgatory Mountain, one of the Appalachian Valley ridges which projects into the valley from the northwest. A narrow outlying ridge, 8 miles long, called Short Hills, and a smaller hill, called The Knob, locally divide the valley lengthwise just north of Buchanan.

The constriction at Buchanan terminates the broad open valley to the north and almost breaks the continuity of the Valley of Virginia itself. Although the part of this broad valley between Lofton and Buchanan is drained southward by the North Branch of James River, it is topographically continuous with the larger part of the valley that is drained northeastward by Shenandoah River, and the whole is therefore called Shenandoah Valley, one of the main divisions of the Valley of Virginia. This should not be confused with the Shenandoah drainage basin, which ends at the divide at Lofton.

Southwest of Buchanan the Valley of Virginia expands again to 10 miles in width, but this continues for only a short distance, for in about 15 miles it is abruptly narrowed to a width of 2 miles by Tinker Mountain, another of the Appalachian Valley ridges that projects southeastward almost across the valley to the Blue Ridge at Cloverdale. This open valley is drained almost entirely by the tributaries of James River, but its extreme southern part is drained southward into the Roanoke by Tinker Creek. Its floor, which is very level where not cut into by the streams,

stands at about 1,500 feet altitude. This division of the Valley of Virginia is called the Fincastle Valley, from the town of Fincastle near its center.

Roanoke is situated in another broad part of the Valley of Virginia, which is about 8 miles wide in its widest part and 20 miles long. This local valley has been called Salem Valley from the City of Salem near Roanoke. It is drained entirely by Roanoke River and its tributaries, the river flowing eastward in the valley to Roanoke, there passing southeastward through a low place in the Blue Ridge. The valley is very irregular in shape, a long arm extending northeast from Roanoke between high mountains of the Blue Ridge, and a smaller arm extending similarly southwestward. Most of its floor is only 1,000 feet in altitude. Southwest of Salem, where the valley narrows to 3 miles in width, the floor is from 1,400 to 1,600 feet in altitude. The Salem Valley is terminated at the forks of the Roanoke, 8 miles southwest of Salem, not by a further constriction of the valley but by its obstruction by the Pedlar Hills, described in the next paragraph.

At the forks of Roanoke River the valley begins to broaden but is obstructed by the Pedlar Hills, a tract of country over 2,000 feet in altitude, through which the main streams flow in narrow gorges 700 to 800 feet deep, giving rise to scenery much more rugged than is common in the Valley of Virginia. The even tops of the Pedlar Hills, which represent the floor of this part of the valley, are 2,000 to 2,200 feet in altitude and are distinctly not a part of the low plain of the Salem Valley about Roanoke, although the area is drained by branches of Roanoke River, but are part of the next valley to the southwest, whose floor has about the altitude of the tops of the Pedlar Hills and is almost continuous with them.

In the vicinity of Christiansburg and Blacksburg, Montgomery County, the Valley of Virginia is 12 miles wide, and farther southwest in Pulaski County it expands to 16 miles. This part of the valley, which includes much of Montgomery, Pulaski, and Wythe counties, is called Dublin Valley. It includes not only the broad open valley around Dublin and Christiansburg but the narrower more rolling valley to the southwest as far as Rural Retreat. In addition to the narrow arm northeast of Christiansburg, whose floor is dissected into the Pedlar Hills country, the valley has another arm which extends northeastward from Blacksburg between Paris and Brush mountains. Twelve miles northeast of Blacksburg this valley arm narrows to less than 2 miles in width and extends as such 12 or 15 miles between parallel mountain ridges to its junction with

the Fincastle Valley northeast of Tinker Mountain. This attenuated valley, which is drained northeastward by Catawba Creek, a branch of the James, is regarded by some as part of the Valley of Virginia. In this report, however, it is regarded as one of the intermontane valleys of the Appalachian Valley Ridges, and the Dublin Valley terminates at the point of constriction, 12 miles northeast of Blacksburg at the low divide between Catawba Creek and North Fork of Roanoke River.

Southwest of Dublin the valley is divided lengthwise by several outlying southwestward trending ridges, more or less connected—Draper Mountain, Lick Mountain, Zion Ridge, Glade Mountain, and Brushy Mountain. The southwest end of Brushy Mountain expands in width and unites with the foothills of the Blue Ridge to the south, thus shutting in the southern part of the valley as a long southwestward extending arm.

Although Dublin Valley is drained chiefly by the tributaries of New River, the river itself flows in the valley but a short distance. Heading in the high plateau country of the Blue Ridge in Tennessee, it enters the Dublin Valley through a narrow gap in the foothill ridge of the Appalachian Mountains and crosses the valley diagonally northeastward to a gap in one of the Appalachian Valley Ridges, through which it passes out of the valley on its northwestward course. This river is unique in the northern Appalachians, for all other major streams flow southeastward from the Appalachian Valley into the Atlantic, whereas New River flows northwestward across the Appalachian Valley and through the Appalachian Plateau into the Ohio and thence into the Mississippi. In terms of drainage, therefore, Dublin Valley is farther from the ocean than any other portion of the northern Appalachian Valley, and its valley floor is correspondingly higher. The floor of Dublin Valley is strikingly level and uniform in altitude over wide areas, especially in the vicinity of Dublin, Christiansburg, and Blacksburg, where it stands at 2,200 feet altitude. The valley floor rises gradually southwestward and there are large level tracts 2,400 to 2,500 feet in altitude near Wytheville, Rural Retreat, and Speedwell. The channels of New River and its tributaries are intrenched about 400 feet into the valley floor, but their slopes are rounded and gentle.

The valley south of the chain of medial ridges ranges from 4 to 8 miles in width. Its northeastern part is occupied by New River and its southwestern part is drained largely by Cripple Creek, a branch of New River, and is locally called Cripple Creek Valley. The extreme southwestern part, which is drained westward by the South Fork of Holston River, is called Rye Valley. The floor of most of the valley south of the medial

hills is between 2,400 and 2,500 feet in altitude, but in Rye Valley and at the west end of Cripple Creek Valley the floor, represented by benches above the stream valleys, has an altitude of 3,000 feet or over. The gentle divide between Cripple Creek and South Fork of the Holston is 2,700 feet.

The valley north of the chain of medial ridges is in general from 6 to 8 miles wide but the part north of Draper Mountain is locally constricted to 3 miles in width by a small outlying Appalachian Valley ridge, inclosing behind it a small reëntrant valley from the northeast. Most of the area north of the medial ridge is drained by Reed Creek, which, however, leaves the valley at Max Meadows and turning sharply southeastward passes between Lick and Draper mountains to join New River. The part of the valley north of Draper Mountain is drained eastward into New River by Peak Creek.

The floor of much of the valley north of the medial ridge is from 2,400 to 2,500 feet in altitude, and grades upward into the low flat rolling summit of Zion Ridge, the divide between Reed and Cripple creeks, at 2,600 feet altitude, and into the broad gentle divide between Reed Creek and Middle Fork of Holston River, near Rural Retreat, at the same altitude. The divide at the head of Reed Creek, which is the highest point on the main line of the Norfolk & Western Railway in the Valley of Virginia and which is about the place where the Valley of Virginia is constricted to a width of 3 miles, is regarded as the southwestern boundary of Dublin Valley.

In Smyth and Washington counties the Valley of Virginia again expands to over 10 miles in width, and from Abingdon to the southern boundary of the State it is 15 miles wide. This part of the valley is called the Abingdon Valley. Much of its floor is between 2,100 and 2,200 feet in altitude, but there is an upper bench or valley floor at 2,300 to 2,400 feet altitude on the tops of level hills just south and southeast of Abingdon, and some parts rise to rounded summits of 2,500 feet altitude. The valley is drained southwestward by branches of Holston River, the Middle and South forks draining the larger part and North Fork the northwestern part.

The Abingdon Valley is divided lengthwise by Walker Mountain. West and northwest of Abingdon a line of rounded hills, the southwestward continuation of Walker Mountain, is only 2,500 feet in altitude. Seven miles northeast of Abingdon the marked ridge of Walker Mountain begins and increases in height and width northeastward. It is accompanied by a parallel ridge called Brushy Mountain northwest of Marion. The part of the valley north of Walker Mountain is about 4 miles wide and is somewhat



Shaded relief map of Virginia. By O. A. Ljungstedt, U. S. Geol. Survey.

hilly because its floor is so largely dissected by the North Fork of Holston River and its tributaries that only small remnants of it are left on flat hilltops 2,500 feet in altitude. A lower valley floor, 2,100 to 2,200 feet in altitude, is also present in places. This arm of the valley ends by the rising of the floor at the head of the North Fork of Holston River north of Rural Retreat where the ridges close in.

The part of the Abingdon Valley south of Walker Mountain is in general about 10 miles wide, but in the vicinity of Marion, where Brushy Mountain projects into the valley from the south, it narrows to 5 miles, and tapers to 3 miles at the head of the Middle Fork of Holston River. The lower floor of this part of the valley rises to 2,300 feet in altitude near Marion. The upper valley floor is also present on the hilltops 2,500 feet in altitude around Marion and rises gradually to 2,600 feet at the low divide at the head of Middle Fork of Holston River, which is the east end of the Abingdon Valley.

A detached valley southwest of Big Stone Gap, which lies west of the Valley Ridges and therefore is not strictly a linear continuation of the Valley of Virginia, is here described with it because it is a northeast arm of the expanded Great Valley in Tennessee, there called the Valley of East Tennessee. It is drained southwestward by Powell River into Tennessee River. Beginning as a very narrow valley near Big Stone Gap, it widens in Lee County to 6 miles, and continues at this width into Tennessee. It is largely a rolling lowland from 1,500 to 1,800 feet above sea level which slopes toward Powell River on its southeast border. The valley lies between Wallen Ridge, one of the Valley Ridges, on the southeast and Cumberland Mountain and Stone Mountain, ridges that represent the Appalachian Plateau escarpment, on the northwest.

Appalachian Valley Ridges.

The Appalachian Valley Ridges occupy the northwestern, and by far the larger portion, of the Appalachian Valley province. (See Pl. I.) This belt expands in width from southwest to northeast. This expansion takes place principally northeast of New River, where there is also a marked change in the trend of the ridges. North of New River the belt ranges in width from 25 miles at New River to about 45 miles at Potomac River, averaging nearly 40 miles. Due to the irregularity of the direction and position of the Virginia-West Virginia State line, this expansion is largely in West Virginia, for, although at New River most of the Valley Ridges lie in Virginia, only a small part of the belt of ridges lies within Virginia

in the northern part of the State, and none of the ridges occur in the northern tier of counties. The trend of the ridges and valleys northeast of New River is about N 30° E, whereas to the southwest they trend mostly N 65° E, this marked change in direction of trend occurring a short distance northeast of New River. This southern part of the belt of Valley Ridges is only 15 to 20 miles wide and lies almost wholly in Virginia.

In the northern part of the Valley Ridge belt there are three chains of more or less continuous prominent mountain ridges. North Mountain is an almost continuous chain of ridges, cut by occasional water gaps, along the east front of the Valley Ridges. In places it is double, and the eastern and lower ridge is there called Little North Mountain and the larger back ridge, Great North Mountain.

In Frederick County, Little North Mountain forms a lone front ridge, hardly high enough to be called a mountain at most places. It continues as a more prominent but broken ridge across Shenandoah County into Rockingham County. Great North Mountain, a much more rugged ridge over 3,000 feet in elevation and unbroken by a stream gap for over 50 miles, begins in Frederick County, forms the northwest boundary of the State across Shenandoah County, and declines in Rockingham County. In the southwestern part of Rockingham County and the northern part of Augusta County, neither Little North Mountain nor Great North Mountain is present, and the open Valley of Virginia is here locally wider. A low straight ridge called Narrow Back Mountain locally forms the front ridge in this region.

Across most of Augusta County and the northern half of Rockbridge County, Little North Mountain is again the front ridge and is paralleled by the larger Great North Mountain. Although it is in many places 3,000 to 3,500 feet in altitude and reaches nearly 4,500 feet in Elliott Knob opposite Staunton in Augusta County, it is not a continuous unbroken high ridge as it is in Shenandoah County. In southwest Rockbridge County and eastern Botetourt County the continuity and direction of these mountains is greatly disturbed and they form a mass of unoriented ridges ending in Purgatory Mountain which projects far into the Valley of Virginia and causes the constriction at Buchanan which terminates Shenandoah Valley. Beyond this mountain complex, North Mountain, locally called Caldwell Mountain in southwestern Botetourt County, forms the boundary between Craig and Roanoke counties, and extends into Montgomery County where it is locally called Brush Mountain. In Roanoke County the mountain belt is again widened by another group of ridges, including such mountains as

Paris, Catawba, Fort Lewis, and Tinker, which lies directly southeast of North Mountain. Most of these ridges are parallel to North Mountain, but at the northeast Tinker Mountain projects far into the valley and causes the constriction of the lowland at Cloverdale which terminates the Fincastle Valley.

Shenandoah Mountain is parallel to and lies about 10 miles northwest of Great North Mountain. It begins in Hardy County, W. Va., and forms the west boundary of Virginia in Rockingham County and the west boundary of Augusta County, dying out in Bath County. It is a massive and rugged mountain 3 or 4 miles wide at its base and unbroken by stream gaps for 70 miles. Throughout this length it is in general over 3,500 feet in altitude, attaining over 4,000 feet in many places. It is one of the main divides in this part of the State and is therefore the backbone of this part of the mountainous belt.

Across Bath and part of Alleghany counties only low and discontinuous ridges follow the trend of Shenandoah Mountain, but southwest of Jackson River a prominent range called Rich Patch Mountain and, farther to the southwest, Potts Mountain, are practically a continuation of Shenandoah Mountain. They are similarly massive and rugged, are over 3,500 feet in altitude, and are unbroken by stream gaps for 50 miles. They form the boundaries between Alleghany and Botetourt counties and the west boundary of the State in Craig County.

Allegheny Mountain, the southwestern continuation of the Allegheny Front where it swings westward in West Virginia, is another of the great mountain ranges of the Valley Ridges, and is the main watershed between the Mississippi and Atlantic drainages in this area. Throughout its length of 100 miles and as well an additional 50 miles of the Allegheny Front northeast to the Potomac River it is not broken by a stream gap, nor crossed by a railroad, except near its southern end where the Chesapeake & Ohio Railroad tunnels through it. Throughout this length it is almost everywhere over 3,500 feet in altitude and in places is over 4,500 feet. It forms the western boundary of the State in Highland, Bath, and Alleghany counties.

There are several other high and prominent mountains between these main ridges but they are relatively short. Those in Virginia worthy of mention here are: Back Creek Mountain and Jack Mountain between Allegheny and Shenandoah mountains in Bath and Highland counties;

Peters—Sweet Spring Mountain between Allegheny and Potts mountains in Alleghany County; Johns Creek Mountain and Sinking Creek Mountain southeast of Potts Mountain in Craig County.

The Valley Ridges southwest of New River are not so prominent or continuous as those to the northeast. Only one, Clinch Mountain, stands out as a bold range forming the backbone of this mountain belt. It begins in Tazewell County and extends unbroken by water gaps or crossed by railroads for 80 miles nearly to the south boundary of the State. It is not a single ridge throughout this length, for in Russell and Smyth counties it comprises a series of massive high sigmoid ridges and a small plateau, mostly over 4,000 feet in altitude. At its northeastern end it forks and takes on parallel ridges, and Garden, Rich, Wolf Creek, East River, and Flat Top mountains are practically its continuation, thus extending it to New River.

Southeast of Garden, Rich, and Flat Top mountains a rather sinuous but continuous ridge from 3,000 to 4,000 feet in altitude, called Walker Mountain, and its smaller companion to the southeast, Little Walker Mountain, a noded ridge about 3,000 feet in altitude, form the outer of the Valley Ridges. The southwestern part of Walker Mountain divides the northeast arm of the Abingdon Valley from the main part of the Abingdon Valley at Marion, and, gradually diminishing in size in that direction, it dwindles to low hills northeast of Abingdon.

The country northwest of Clinch Mountain is crossed by only a few distinct linear ridges but is classed with the Valley Ridges rather than with the open valley country because of its generally hilly character. Copper Ridge, a low elevation of rounded summits about 2,500 feet in altitude, is its principal feature. Northeastward, where it is called Kent Ridge, other more prominent though diminutive mountain ridges, such as Elk Garden Mountain and Paint Lick Mountain, occupy part of the belt. Southwestward this low ridge continues to the State line under the name Big Ridge. Two more prominent mountain ridges, Wallen Ridge and Powell Mountain, form the western part of the Valley Ridge belt where the Appalachian Valley is widened by the Plateau escarpment swinging westward.

Massanutten Mountain and other smaller outlying ridges in the Valley of Virginia are regarded as outliers of the Valley Ridges. From the valley floor Massanutten Mountain appears as a single level-topped ridge with steep slopes and abrupt ends. (See Pl. II.) It is in reality composed of two or more parallel ridges, which are unbroken by water gaps for nearly



(A) Massanutten Mountain and Woodstock Gap.



(B) South end of Massanutten Mountain, seen from Harrisonburg.

45 miles. It has a general altitude of 2,700 feet. The northern half is composed of 2 parallel ridges 4 miles apart separated by a deep valley that drains northward, passing out through a rocky gorge between the ends of the ridges. The southern half is less simple, being composed of 3 and in some places of 4 parallel ridges, straight, others curved and sigmoid, and more or less cut into segments by small stream gaps.

All of the northern part of the Valley Ridges in Virginia is drained either into the Potomac or the James. The small areas of Valley Ridges in Frederick, Shenandoah, and Rockingham counties are drained by the North Fork of Shenandoah River or by other tributaries of Potomac River. A small part of Highland County is drained by the headwaters of the South Branch of Potomac River, which flows northeastward through the wide belt of Valley Ridges in West Virginia. Most of the rest of the northern part of the Valley Ridge belt in Virginia is drained eastward by James River and its many tributaries. Short tributaries of New River head south of Newcastle and drain part of Craig County, and most of Giles and of Bland counties are also drained by New River, which crosses midway through Giles County and flows northwestward into the Appalachian Plateau. The southwestern part of the Valley Ridges is drained southwestward chiefly by Clinch River and its tributaries, but the southeastern border is drained by the North Fork of Holston River.

APPALACHIAN PLATEAU.

The Appalachian Plateau, which borders the Appalachian Valley on the northwest, lies mostly in West Virginia, so that only the small part that crosses the southwest corner of Virginia needs to be here described. In Tazewell County, where the plateau enters from West Virginia, its surface is so cut into by streams that it does not in the least resemble a plateau. Remnants of the plateau surface, which are preserved in the flat tops of several southwestward trending ridges and of branching ridges which trend at right angles, become more numerous and prominent toward the southwest. In Scott County, the plateau is better preserved in the prominent, nearly flat-topped mountain southeast of Big Stone Gap called Powell Mountain. (This is not a continuation of one of the Valley Ridges of that name to the southwest.) The Appalachian Plateau is here offset to the west about 10 miles by Powell Valley and associated Valley Ridges. West and southwest of Big Stone Gap a linear ridge of the Valley Ridge type, here called Stone Mountain and farther southwest Cumberland Mountain, is in reality

the remnant of the east-facing escarpment of the Appalachian Plateau, as is more plainly shown a short distance over the State line in Tennessee.

PHYSIOGRAPHIC FORMS.¹

Viewing the Appalachian Valley province in a broad way it is noticeable that in most of the wider valleys, especially the open valleys that comprise the Valley of Virginia, there is a gently sloping lowland which forms the valley floor, in which the streams lie in narrow channels below its level. This is well shown in the profiles across and along the Valley of Virginia in Plate III. On the mountain summits also there is an upland level to which most mountains rise and above which few stand, but this upland level is not so apparent as is the valley floor. It can best be observed from some mountain top slightly above this level, from which the summits of several even-topped ridges and mountains can be seen, which will appear to fall into a plane. It may be seen also on good topographic maps, which can be studied to advantage by coloring with crayon the flat tops of ridges whose elevations correspond approximately with the level being studied and imagining all lower areas to be filled to this level, thus restoring the old surface.

On closer study it may be found that the valley floor in places is made up of two or more benches at levels 100 feet or so apart, instead of a single flat surface. It is also to be noted in many places that some of the tops of the Valley Ridges and of the Blue Ridge which do not rise to the upper level form an intermediate level. It is concluded by those who have studied these conditions most carefully, seeking to learn their mode of origin, that such level tops of mountains and benches observable in the present land surface are remnants of plains of low relief that were parts of former land surfaces; that these plains of low relief resulted from the gradual but more or less complete wearing away of the elevated portions of the land composed of the softer rocks and, in some cases, of even the hardest rocks by weathering and by stream and rain erosion; that the highest of these plains was formed first and that the other lower plains are successively younger in the order of their altitude and were formed by cutting away the softer parts of the higher plains that preceded it. These erosion or planation planes, or worn down land surfaces, are generally called peneplains, so those of the various levels observed in the Appalachian Valley of Virginia will be referred to for convenience in this report as the "summit peneplain,"

¹ Written by G. W. Stose.

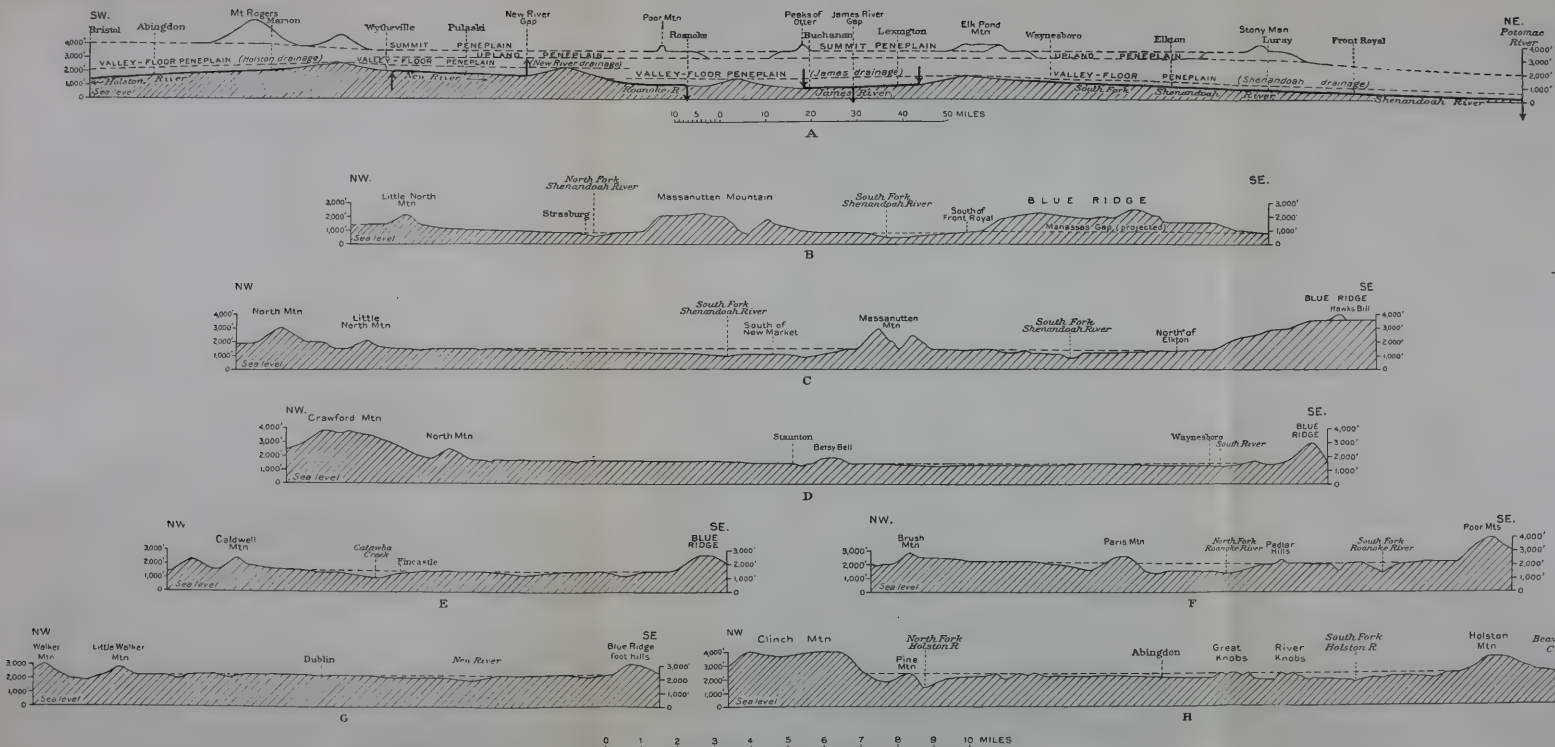


Plate III.—Generalized profile sections of the Valley of Virginia showing penneplain surfaces described in this report.

- A. Longitudinal section along the valley from Bristol to Potomac River. The arrows indicate direction of drainage, down meaning southeast and up, northwest.
 B. Cross section of the valley south of Strasburg and Front Royal.
 C. Cross section of the valley south of Newmarket and north of Elken.

- D. Cross section of the valley near Staunton and Waynesboro.
 E. Cross section of the valley near Fincastle.
 F. Cross section of the valley southwest of Salem.
 G. Cross section of the valley near Dublin.
 H. Cross section of the valley through Abingdon.

the "upland peneplain," the "intermediate peneplain," and the "valley-floor peneplain," as given in figure 2, page 20.

The process of the formation of these gently sloping surfaces or peneplains is interpreted as follows: At the time of the formation of the "summit peneplain" this region stood somewhat above the sea so that the rocks at its surface were attacked by the atmosphere. As they became weathered by the action of air, rain, frost, and the heat of the sun, they partly dissolved and disintegrated into small particles, which were carried off by the rain, rivulets, and larger streams, just as they are to-day. The waste was first carried to lower elevations on the land, but eventually was carried into the sea. This process is very slow, and the immediate effect on the land was small, but after thousands of years of continuous erosion the cumulative effect was appreciable, and in still longer periods of time the changes were great. The softer and more soluble rocks were removed more easily and quickly than the harder and less soluble rocks, and the areas occupied by them became lowlands. The alternate layers of intricately folded hard and soft rocks, that composed the earth were thus eroded so that parallel valleys underlain by softer rocks were separated by ridges composed of hard rock, just as they are in the Appalachian Valley to-day. When the valley bottoms approached sea level, the power of the streams to cut their channels deeper diminished but they continued to widen their valleys, and push the divides back and gradually to lower them. This wearing away of the land continued for so long a period that even the harder rocks were worn down to low rounded hills and the rest of the land surface was reduced to a gently rolling plain or peneplain sloping gently toward the master-stream valleys and toward the sea. The planing down process was finally interrupted by an earth movement which elevated this part of the continent, raising the land surface and tilting it more steeply toward the sea. This renewed the activity of the eroding processes and caused the streams to again cut their channels deeper. The parts of the uplifted peneplained land surface that were composed of softer rocks were worn away and only those parts of the old surface that were composed of harder rocks were left standing as mountains. To-day only narrow remnants of this old surface remain on the tops of some of the highest ridges in the Appalachian Valley and Appalachian Mountains, and the evidence of an old land surface at this level that once extended continuously across the valleys is very meager.

After the elevation of the land just referred to it again remained nearly stationary for another long period, and another gently rolling surface, or

penepplain, not so extensive as the first, was formed, above which rose hills or mountains composed of the hardest rocks. The cutting of the second penepplain was likewise terminated by an uplift of the land and the same process was repeated several times.

The even floors of the various parts of the Valley of Virginia and of many of the broader intermontane valleys, into which the channels of the present streams have been cut, represent a penepplain of similar origin formed at a later epoch, and as these valley floors are only on the softer and more soluble rocks (shale, thin sandstone, dolomite, and limestone), the time occupied in their formation was not so long as that of the earlier epochs when some of the harder rocks were also worn down. Although the floors of the several parts of the valley are not at the same level, they were probably formed during the same general epoch of erosion, their difference of level depending on the distance of the area from the sea along the line of drainage which existed at the time the penepplains were formed. These penepplains consisted of gently rolling lowlands or wide flat-bottomed valleys along the major streams which ascended inland from sea level at a gentle grade, such as a balanced graded stream would maintain. The flat bottoms of the valleys sloped up gently on either side to where the ridges of hard rock rose abruptly from the lowland, except where the ridges were cut by gorges or ravines, and here streams issuing from the mountains poured a mantle of cobbles, gravel, and sand over the lowland surface in the form of an alluvial fan or cone. Such alluvial fans naturally stood a little higher than the rest of the lowland surface. These gravel-strewn slopes or plains are found at many places in the Valley of Virginia and other open valleys.

Since the formation of these lowlands or valley floors, the land has again been elevated several times but each of slight amount. These uplifts have occurred at such short intervals that the streams were able to cut only narrow flat-bottomed valleys into the old floor, which now appear as benches in a belt a mile or two wide on either side of the main streams. These benches rise in successive levels above the stream channels step-like to the valley floor. The stream channels are in general 200 to 300 feet below the valley floors, although some streams that have been diverted to another drainage system are as much as 800 feet below their valley floor. The winding courses of many streams, especially those which occupy deep narrow gorges, were established on the valley floor when its surface was near base level and had been worn down to such a gentle grade that aggrading streams flowed sluggishly across it in meandering courses. Their winding channels were preserved by being cut into the valley floor when the

stream grades were increased by the next uplift of the land and they have since been gradually deepened and increased in curvature.

The geologic ages in which the old land surfaces or peneplains and valley floors in the Appalachian region were formed are not definitely known, but they are believed to range from Jurassic to Recent. The highest peneplain that is recognized in Virginia ranges in altitude from 3,500 to 4,000 feet above sea level. Near the Potomac the Blue Ridge seems to have been entirely eroded below this level by later erosion. Near Luray broad flats and gentle divides on the tops of the Blue Ridge at 3,500 feet altitude probably represent the peneplain, above which stand Stony Man and other peaks that were unreduced and are about 4,000 feet in altitude. South of Waynesboro the Blue Ridge has a general altitude of 3,500 feet, although some ridges and peaks rise to 4,000 feet and over. On both sides of the James River gorge and as far south as the Peaks of Otter the general altitude of the Blue Ridge is about 3,500 feet with peaks up to 4,000 feet. In the vicinity of Roanoke River the Blue Ridge is broken down below this peneplain level, but to the southwest many of its even-topped ridges are 3,500 feet. In Iron Mountain, still farther southwest, the even tops of the higher mountains rise to 4,000 feet altitude.

The higher ridges in the valley have similar elevations. The massive Shenandoah or Great North Mountain is the chief mountain mass within the valley in the northern part of the State that persists at the highest level. Its rounded summits are mostly between 3,500 and 4,000 feet, but one peak and an outlying knob near Staunton are distinctly above the level and rise to nearly 4,500 feet altitude. Between Shenandoah Mountain and Allegheny Front in West Virginia are many straight narrow ridges whose tops also vary between 3,500 and 4,000 feet. The Allegheny Front rises gradually from 3,000 feet altitude near the Potomac to over 4,000 feet west of Woodstock, Va., and its southwestward extension in Allegheny Mountains, as well as the Back Allegheny Mountain paralleling it on the west, rises to over 4,500 feet northwest of Staunton. These highest points have been protected from erosion by massive flat-lying Pennsylvanian sandstones which compose them, and they probably do not represent the old peneplain surface but stood somewhat above it, as the highest mountains farther southwest are much lower, between 3,500 and 4,000 feet in altitude. Southwest of Tazewell many of the higher mountain tops are about 4,000 feet, above which a few peaks rise to 4,500. This is especially well shown on Clinch Mountain, north of Saltville, where the general level of the mountain top is 4,000 feet but many sharp rocky peaks rise to about 4,500 feet.

This highest peneplain is believed to have been the surface of the land in a very early stage of the development of the present features, and therefore has suffered most from erosion. Few if any of its remnants can be actually found, and its exact level, therefore, cannot be determined. It is probably older than the Kittatinny peneplain, so well developed on Kittatinny and other mountains in Pennsylvania at 1,600-foot altitude, and as that peneplain is believed to be early Cretaceous or late Jurassic in age, this 3,500 to 4,000-foot peneplain is probably still older. It will be referred to in this report as the "summit peneplain." (See fig. 2.) The manganese deposits on the tops of Round, Flat Top, and Johns Creek mountains at altitudes of 3,000 to 3,800 feet, were probably in part formed on this old peneplain.

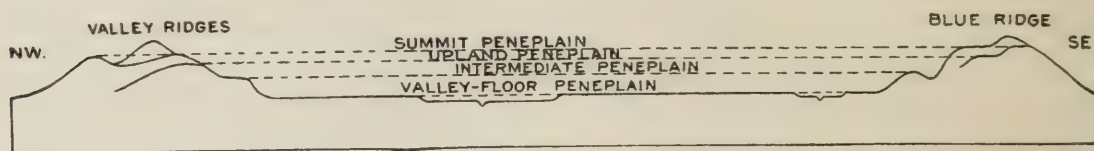


Fig. 2.—Ideal profile section across the Valley of Virginia showing the peneplain surfaces described in this report. The upland peneplain is regarded as Jurassic or early Cretaceous in age and the summit peneplain is probably still older. The intermediate peneplain is regarded as Upper Cretaceous in age; the valley-floor peneplain as early Tertiary in age; and a lower valley-floor terrace, where present, as late Tertiary in age.

The next lower peneplain is best represented in Virginia probably by the Blue Ridge plateau southwest of Roanoke. This plateau, which still has a gently rolling surface only slightly trenched by streams, stands prominently above the lowlands on the northwest and southeast and apparently is a relatively unmodified part of the old land surface that was cut on hard resistant rocks. Its general altitude is 3,000 feet, above which rise low rounded hills and in places mountain ridges 3,500 to 4,000 feet border it. This peneplain is not so clearly discernible in the Blue Ridge north of the Roanoke where the 3,500-foot plain predominates, but traces of it may be detected in many places, and northeast of Waynesboro broad rounded tops of the Blue Ridge about 3,000 feet in elevation apparently represent it. In the Blue Ridge near Front Royal it apparently descends to 2,500 feet, and the tops of some of the northern valley ridges at 2,500 feet altitude are probably also remnants of the peneplain. The region west of the Blue Ridge, except the northern part which drained north into the Potomac, apparently drained westward at the time this peneplain was being formed and it was therefore far from the ocean along its drainage line. This area

therefore was probably not reduced to so low a level nor to so gentle a surface as the Blue Ridge area. Most of the Appalachian Valley Ridges of western Virginia and the adjacent part of West Virginia, except the highest ones 4,000 feet or higher, range from 3,000 to 3,500 feet, and were not fully reduced to the peneplain level. It is probable that some of the round mountain tops and benches on the mountain sides at altitudes of 2,700 to 3,000 feet south of Bluefield, on which manganese deposits occur, may represent this peneplain.

This is believed to be the same peneplain as that present on the mountain tops in Maryland and southern Pennsylvania 1,900 to 2,000 feet elevation and the one called Kittatinny peneplain in the northern Appalachians, named from Kittatinny Mountain in Pennsylvania and New Jersey, which has an altitude of 1,600 feet. It is believed to be of Jurassic and Cretaceous age. This peneplain in Virginia will be referred to in this report as the "upland peneplain." (See fig. 2.)

A still lower peneplain is indicated by the even tops of foothill ridges, spurs, and knobs of the Blue Ridge and by some low divides in these mountains about 2,200 to 2,300 feet in altitude. It is not generally so well defined as the two higher plains, because the erosion period during which it was formed was not so long, and it was therefore cut only on rocks of moderate hardness. The foothill knobs and spurs of the Blue Ridge are composed of such rocks, and the Blue Ridge and similar mountains which are composed of still harder rocks stood above the peneplain and preserved remnants of the older plains. Some wind gaps in the Blue Ridge, particularly those east of Massanutten Mountain at 2,250 feet altitude, were probably old stream channels that were occupied at this time by streams that flowed on the old land surface and passed through the Blue Ridge at these places. They were later abandoned when the land was elevated and valleys were cut below this level on adjacent softer rocks. The region west of the Blue Ridge and south of the Potomac drainage basin was not reduced to this level because it was drained westward and was therefore far from the ocean. In the Potomac drainage basin there are evidences of the presence of this peneplain on low ridges and spurs, and it is believed to be the same as that represented by broad level tracts 1,400 to 1,500 feet in elevation in the mountains of southern Pennsylvania cut on rocks of moderate hardness. This has been called the Weverton peneplain from the town of that name on the Potomac, in Maryland, where the rather even crest of the Blue Ridge is 1,400 feet. The age of this peneplain is not known, but it is supposed to have been

formed during middle and late Cretaceous time, and is generally referred to as the Upper Cretaceous peneplain. In this report it will be called the "intermediate peneplain." (See fig. 2.)

A younger group of peneplains has been recognized in this region which is here called the "valley-floor peneplains." Its various parts have different levels, depending on the drainage system in which the floor was developed and the distance along its water course from the ocean. In Shenandoah Valley, which drained to the ocean through the Potomac, the valley floor ranges in altitude from 600 feet at the Potomac to 1,800 or 2,000 feet at its head. Above the forks in Shenandoah River, where the valley is divided lengthwise by Massanutten Mountain, the floors of the two parts of the valley have slightly different altitudes and their drainage systems were probably separate at that time. The southeastern part is the lower and its floor rises to about 1,800 feet altitude at the divide at Lofton. The northwestern part rises to 2,000 feet on the divide at Middlebrook. This peneplain has been called the Shenandoah¹ in Virginia, and is believed to be the same as the Harrisburg peneplain north of the Potomac which is so well developed in the vicinity of Harrisburg, Pennsylvania.

The peneplain that forms the floor of the Fincastle Valley, remnants of which occur also in the Salem Valley and in the intermontane valleys to the north, is 1,500 feet in altitude. This plain was formed by the erosion of the James River system, and its lower altitude is due to its being nearer the ocean by that direct course. The floor of the Dublin Valley, including Cripple Creek and Rye valleys at its upper end, is 2,200 to 2,700 feet in altitude. The higher altitude of its floor is due to the drainage of its area westward through New River to the Ohio, and its correspondingly longer distance from the ocean base level. The floor of the Abingdon Valley is likewise high, 2,300 to 2,600 feet in altitude, because it is far from the ocean base level by way of the Holston River and Tennessee River to the Mississippi.

Most of the intermontane valleys have similarly flat lowland floors which stand above the present stream beds, and the altitude of each depends chiefly on the drainage system to which it was tributary at the time the plain was formed. Those that were tributary to Shenandoah River below its forks have an altitude of 1,500 to 1,600 feet. Mineral Ridge and other ridges at about this level in western Shenandoah and Frederick counties,

¹ Watson, T. L., and Cline, J. H., Univ. of Va. Phil. Soc. Bull., vol. 1, No. 17, p. 360, 1913.

on whose rounded summits the manganese deposits around Zepp occur, are remnants of this peneplain. (See Plate XX.) The intermontane valleys that were tributary to the North Fork of the Shenandoah are from 1,700 to 2,000 feet in altitude.

Those valleys which are now drained chiefly by the headwaters of the James, the northern parts of which, however, are drained northward by the headwaters of the Potomac, have floors between 2,500 and 3,000 feet in altitude, and it is believed that at the time they were formed they were tributary to New River whose floor was at this level. Their drainage has since been diverted by stream capture to the more direct course to the ocean by James River, which had a much steeper gradient. The valley floor of Sinking Creek valley, on which the manganese deposits around Hoffman occur, is part of this peneplain. The intermontane valleys tributary to the James around Covington, whose floors are 1,500 to 2,000 feet in altitude, were evidently part of the James drainage system at the time their floors were cut. The valleys which are adjacent to New River and were drained by that stream have floors that are mostly 2,300 to 2,500 feet in altitude, but rise to 3,000 feet at their distant heads. Many of the manganese deposits on low benches and terraces at about this altitude in Bland and Giles counties were probably formed on this peneplain. Some of these valleys have more recently been captured by the James River drainage and their old floors have been deeply dissected and in places obliterated by the recent streams.

All these valley floors are believed to have been formed during the same general epoch, probably in early Tertiary time, but they cannot be called a single peneplain because of their diverse levels. They will be referred to in this report as the "valley-floor peneplains" of early Tertiary age.

Later erosion of the softer rocks to a new low level, 100 to 500 feet lower than the valley-floor peneplains, is believed to have occurred in late Tertiary time, probably just before and during Pliocene time. This lower valley floor is considered to be of the same age as the peneplain so well marked along the Atlantic coast by high-level gravels, formerly called Lafayette. In the Appalachian Valley this epoch of erosion is chiefly represented by low flat divides in the valley floor of longitudinal valleys underlain by soluble or soft rocks, and by terraces and benches on somewhat harder rocks along the transverse trunk streams. These terraces are well marked along Potomac River but cannot be definitely traced far from the river except up the main tributaries. The valley floor of Salem Valley,

1,000 feet in elevation, was probably formed at this time, when Roanoke River robbed the James of one of its large branches that formerly drained this valley.

There are narrow terraces and benches at still lower levels along the major transverse streams, most of which are still covered by stream gravels, and these were undoubtedly formed in Pleistocene time, for those along Potomac River contain glaciated and iceborne boulders. These benches cannot at present be correlated with one another nor with well-defined terraces of similar age along the Atlantic coast which have wide extent and mark three to four distinct successive levels of the sea in Pleistocene time.

GEOLOGY¹

THE ROCKS.

The rocks exposed in the valley portion of the Appalachian Valley are chiefly limestones and dolomites with a minor amount of shale. The rocks composing the Valley Ridges are chiefly sandstones and shales, with some limestones. These are all called sedimentary rocks because they were deposited as sediment from water, as compared with some of the older crystalline rocks of the Appalachian Mountains, which were once molten like lava and are called igneous rocks. The older crystalline rocks formed the floor and shore of the sea in which the sedimentary rocks were laid down, and are among the oldest rocks known. The first sediments deposited in this sea were sands and sandy muds which now form the hard sandstones, quartzites, and slates exposed in the Appalachian Mountains bordering the Appalachian Valley on the east.

The rocks of the Appalachian Valley, with which this report is chiefly concerned, have been divided into the following formations arranged in the order of age, oldest at the bottom, and which will be described in order from the oldest to the youngest.

The formations vary in character and thickness along their strike and also across their strike, and they are not all present in every section across the State, for some were deposited and later eroded in places before succeeding deposits were laid down, and others were deposited in only a limited area and their edges were overlapped by later sediments, thus causing a break in the sequence, called an unconformity. The distribution of these formations at the surface is shown on the folded geologic map, Plate IV, accompanying this report. Because of the small scale of the map, the formations are there grouped into 8 mapped units.

Shady dolomite and Watauga shale.

The Shady dolomite is composed chiefly of massive coarse-grained glistening dolomite, and is overlain by the Watauga shale, a purplish sandy shale and sandstone with some interbedded limestones. These formations occur chiefly along the southeastern side of the valley close to the foot of

¹ Written by G. W. Stose.

Formations of western Virginia.

Age.	Southwestern Virginia.	Middle-western Virginia.	Northwestern Virginia.
Carboniferous.	Newman limestone.	Newman limestone.	Greenbrier limestone.
	Grainger shale.	Price sandstone.	Pocono sandstone.
Devonian.	Black shale.	Kimberling shale.	Hampshire formation (Catskill).
	Shale of Genesee age.	Shale of Genesee age.	Jennings formation { Chemung Portage. Genesee.
	(Absent in most places.)	(Absent in part.)	Romney shale { Hamilton. Marcellus. Onondaga.
	Hancock limestone.	Oriskany formation.	Oriskany formation.
	Giles formation.		Helderberg limestone.
Silurian.	Shale, sandstone, and limestone of Cayuga age.	Lewistown limestone.	Cayuga group
	Clinton formation.	Clinton formation.	Clinton shale.
	Clinch sandstone.	Clinch sandstone.	Tuscarora sandstone.
Ordovician.	Red sandstone and shale.	Red sandstone and shale.	Red sandstone (Junata ?).
	Martinsburg shale.	Martinsburg shale.	Martinsburg shale.
	Moccasin limestone.	Liberty Hall limestone.	Chambersburg limestone.
	Athens shale.		
	Chickamauga limestone.	Murat limestone.	Stones River limestone.
	Fine-grained limestone.		
Cambrian.	Knox dolomite.	Natural Bridge limestone.	Beekmantown limestone.
	Nolichucky shale.		Conococheague limestone.
	Honaker limestone.		Elbrook limestone.
	Watauga shale.	Watauga ("Buena Vista") shale.	Waynesboro shale.
	Shady dolomite.	Shady dolomite ("Sherwood limestone").	Tomstown limestone.
Pre-Camb.	Quartzites, sandstones, slates, and older rocks, chiefly igneous, of the Appalachian Mountains.		

the Appalachian Mountains, where they are manganese bearing in many places. Their distribution and relation to the manganese deposits were described in detail in a previous report¹ and this will not be repeated here. Both formations are apparently present in normal thickness and retain their distinguishing characteristics across the State. Near Natural Bridge the Shady has been estimated to be 1,800 feet thick and the Watauga 900 feet, but the shale thins to 460 feet near Abingdon. The Shady dolomite is locally known as the "Sherwood Limestone"² in middle-western Virginia and is essentially the same as the Tomstown limestone in northwestern Virginia, Maryland, and Pennsylvania. The Watauga shale is the same as the "Buena Vista" shale in middle-western Virginia and the Waynesboro shale in Maryland and Pennsylvania. Where exposed in faulted anticlines near the northwestern side of the Abingdon Valley the shale and an underlying dolomite, presumably Shady, are together called Russell formation.

Honaker limestone and Nolichucky shale.

In Tennessee relatively pure limestones lie between the Watauga shale and a higher shale called Nolichucky. The limestones are there known as the Rutledge and Marysville limestones, and are separated by a thin shale called Rogersville shale, which in Virginia becomes so calcareous that the three formations can not generally be readily separated and are therefore known as the Honaker limestone. The Nolichucky also becomes calcareous northeastward in Virginia and loses its identity, so that it can not be traced far into the State. These four formations correspond to the lower part of the Natural Bridge limestone of central-western Virginia and to the Elbrook formation in northern Virginia and Maryland. The Rutledge, Rogersville, Marysville, and Nolichucky formations have a combined thickness of about 1,500 feet near Bristol, Va., and the Honaker limestone is 1,400 feet thick in Russell County. The Elbrook formation is 3,000 feet thick in Maryland.

Knox dolomite.

The Knox dolomite is an alternation of thick beds of dolomite, thinner bedded blue magnesian limestone, and massive chert layers. In the vicinity of Abingdon the lower part is largely coarse dolomite which weathers to deep red soil, in places full of white chert fragments, and the upper part is largely interbedded blue limestone and gray magnesian limestone. In the southwestern part of the State the lower dolomite beds contain so much

¹ Va. Geol. Survey Bull. XVII, 1919.

² Campbell, H. D., Am. Jour. Sci. (4), 1905, Vol. XX, pp. 445-447.

chert that it accumulates in the soil and produces low rounded ridges locally named Copper Ridge, Kent Ridge, and Moccasin Ridge. A few fossils of Cambrian age have been found in these lower beds. The upper limestones contain gastropods of Beekmantown (Ordovician) age. The total thickness of the formation is about 4,000 feet. The Knox is equivalent to the upper part of the Natural Bridge limestone of central-western Virginia. Its lower dolomite beds are in part equivalent to the Conococheague limestone of Maryland and Pennsylvania. In the southwestern part of the State, and extending into Tennessee, the chert of the formation carries manganese deposits which have been prospected at many places and have been mined near Tiptop, Tazewell County, Va. In Bland, Giles, and Craig counties the chert-bearing limestone of this general age is referred to in the description of the mines in this report as Knox dolomite although it may contain representatives of older limestones.

Chickamauga limestone, Athens shale, and Moccasin limestone.

Overlying the massive dolomite and limestone beds of the Knox are non-magnesian limestones and calcareous shales. In southwestern Virginia the names Chickamauga limestone, Athens shale, and Moccasin limestone, in use in Tennessee and Alabama, have been applied to these formations. In most of the Abingdon region the lower limestone is fine-grained and of Stones River (lower Chazy) age, and is overlain by black calcareous shale which contains fossils also of Chazy age and probably represents some of the beds of limestone elsewhere. These two formations together have a thickness of about 1,000 feet. Northwestward, across the strike of the rocks, the shale thins and gradually disappears and the fine-grained limestone is also absent in places. Coarse granular light-gray limestone which there overlies them or takes their place, contains fossils of upper Chazy age and is called the Holston marble. In middle-western Virginia the corresponding limestone is called Murat.

Overlying the Chickamauga limestone and Athens shale in the southwestern part of the State are reddish impure limestones and calcareous shale, about 400 feet thick, called Moccasin limestone. Its fossils are of Black River age and it is about equivalent to the Liberty Hall limestone of middle-western Virginia, which is a dark argillaceous knotty limestone, 1,000 feet thick. The Liberty Hall limestone and part of the underlying Murat limestone are, according to Bassler¹, equivalent to the Chambersburg limestone of Maryland and northern Virginia.

¹ Bassler, Ray S., Cement Resources of Virginia, Va. Geol. Surv. Bull. 11A, 1909.



(A) Clinch sandstone cliffs and talus. Greenland Gap in New Creek Mountain, Grant County, W. Va.



(B) Clinch Mountain west of Saltville.

Martinsburg shale and overlying red sandstone and shale.

A thick series of gray shale, generally known as the Martinsburg shale, overlies the limestones of the Appalachian Valley across the State. It has been called Sevier shale in geologic folios covering the southwestern part of the State because it was thought by some geologists to be the equivalent of the Sevier shale of Tennessee, but it is now known to be different from the typical Sevier shale. It contains abundant fossils identified by E. O. Ulrich as of upper Trenton and Eden age. It is in general 800 to 1,000 feet thick, and is very persistent in the main valley belt across the State, maintaining approximately the same thickness and relation everywhere. On the northwestern side of the Appalachian Valley, however, it is either absent or in part represented by granular limestone.

The Martinsburg shale is generally succeeded by red sandstone, sandy shales, and thin sandy limestone, about 500 feet thick, which contain fossils of Upper Ordovician (Maysville) age in their lower part. In southwestern Virginia these beds have been called Bays sandstone, a name that is in use in Tennessee for similar red sandstones. The typical Bays sandstone of Bays Mountain, in Hawkins and Greene counties, Tennessee, however, is considerably older, probably of Trenton and Black River (Middle Ordovician) age, and therefore not equivalent to the red sandstones and shales here described, and the name Bays sandstone cannot properly be applied to them. In the northwestern part of the State the name Juniata, used in Maryland and Pennsylvania for similarly situated red sandstones but apparently of Richmond age, has been applied.

Clinch sandstone.

Many of the mountains in the Valley Ridge belt are composed of hard light-gray to white sandstone of Medina (Silurian) age. This very massive sandstone is called Clinch sandstone throughout most of Virginia, but in the northern part the name Tuscarora sandstone, in use in Maryland, is applied. On Massanutten Mountain the white sandstone of Medina age and underlying yellowish sandstones are together called Massanutten sandstone. In the southern part of the State, where the sandstone makes the massive Clinch Mountain (see Pl. V.), its pure quartzose beds, each 20 to 30 feet thick, aggregate about 200 feet. In northern Virginia, where it makes Cacapon Mountain and other high ridges, it is not so massively bedded but reaches 270 to 300 feet in thickness. Where cut by a stream gorge it makes rocky cliffs bordered by a talus of huge blocks. (See Pl. V.) It is almost barren of fossils.

Clinton formation.

A series of shales, thin sandstones, some thicker sandstones and red ferruginous quartzites, and iron ore beds overlie the Clinch sandstone. Fossils, which are generally plentiful, are of Clinton age. A heavy sandstone at the base is locally called Cacapon sandstone in middle-western Virginia. A hard, well-bedded slabby, light-gray quartzite containing casts of *Scolithus* tubes and having rippled, trail-marked, and otherwise rough-bedding surfaces has been observed by the authors at the top of the formation at many localities across the State, and is generally easily recognizable. It is especially noticeable in Bland and Giles counties and farther southwest. It is believed to be equivalent to the Keefer sandstone member of Pennsylvania and Maryland, which was formerly referred to the base of the Cayuga formation but has been more recently correlated with the Clinton.

In the southwestern part of the State the Clinton formation and some overlying sandstones and limestones of Cayuga age have in previous reports been called Rockwood, because of their supposed equivalence to the "Rockwood" formation of Tennessee. The Clinton proper in the Abingdon region is about 250 feet thick. Farther southwest, in the Big Stone Gap region, it is about 500 feet thick. In the northern part of the State it is 500 feet thick.

Rocks of Cayuga and Helderberg age.

Limestones generally overlie the Clinton. Those at the base are mostly thin-bedded light-gray, impure, laminated, and shaly, (see Pl. VI) and contain fossils of Cayuga age. Those above are mostly massive, blue, and purer, and contain fossils of Helderberg age. This great mass of limestone is called Lewistown in middle-western and northwestern Virginia. These limestones vary greatly in character and thickness along their strike in Virginia. In the northern part of the State the shaly limestones of Cayuga age are about 1,000 feet thick and the more massive beds of Helderberg age are about 300 feet thick. Southwestward, the limestones seem to thin and the siliceous impurities apparently increase, so that in the central-western part of the State it is largely a massive sandstone. This is well shown in the section at Eagle Rock, at the James River gap in Rat-hole Mountain, where the rocks are largely a massive white sandstone, and the Cayuga and Helderberg equivalents have not definitely been distinguished from the Clinch below or the Oriskany above. The section is as follows:



(A) Finely laminated limestone of Cayuga age. From west slope of Bonnet Hill, Shenandoah County.



(B) Soft manganiferous sandstone overlain by thin-bedded chert, both of Oriskany age. Honaker prospect one-half mile northwest of Rocky Gap, Bland County.

Section at Eagle Rock, on the east side of the James River gap in Rathole Mountain.

Formation.	Feet.	Description
Black shale.		Black shale, probably of Genesee age.
Oriskany sandstone.	193	Dark, granular, mostly thick-bedded sandstone. Rough, ripple-marked bedding surfaces. Few thin shaly sandstone beds. No fossils seen. Probably of Oriskany age.
— ? —	36	Covered.
Rocks of Cayuga and possibly of Helderberg age.	55	Pure, white, saccharoidal sandstone. Weathers crumbly.
	70	Massive, vitreous, white to gray sandstone. Weathers rusty and red stained; finely laminated at base. Two shaly partings, lower one dark graphitic.
	50	Covered.
Clinton formation.	430±	Mostly thin-bedded, gray to rusty sandstone ledges and concealed spaces, probably shale. Some beds are ripple-marked and cross-bedded, and some are red and ferruginous.
	115	White quartzose sandstone, crossbedded, laminated, and irregular bedded. Weathers rusty. More massive at base.
	110±	Covered.
Clinch sandstone.	330±	Mostly hard, white to gray massive sandstone. Thinner bedded and soft in lower part, enclosing a 40-foot bed of massive white coarse sandstone with scattered ½-inch quartz pebbles.
	15+	Alternate shale and sandstone.

In the Abingdon region the limestones of Helderberg age are apparently entirely absent and only 127 feet of impure finely laminated magnesian limestone and calcareous gray sandstones of Cayuga age are present below the Oriskany, as shown in the following section:

Section on Tumbling Creek, 5 miles west of Saltville, Va.

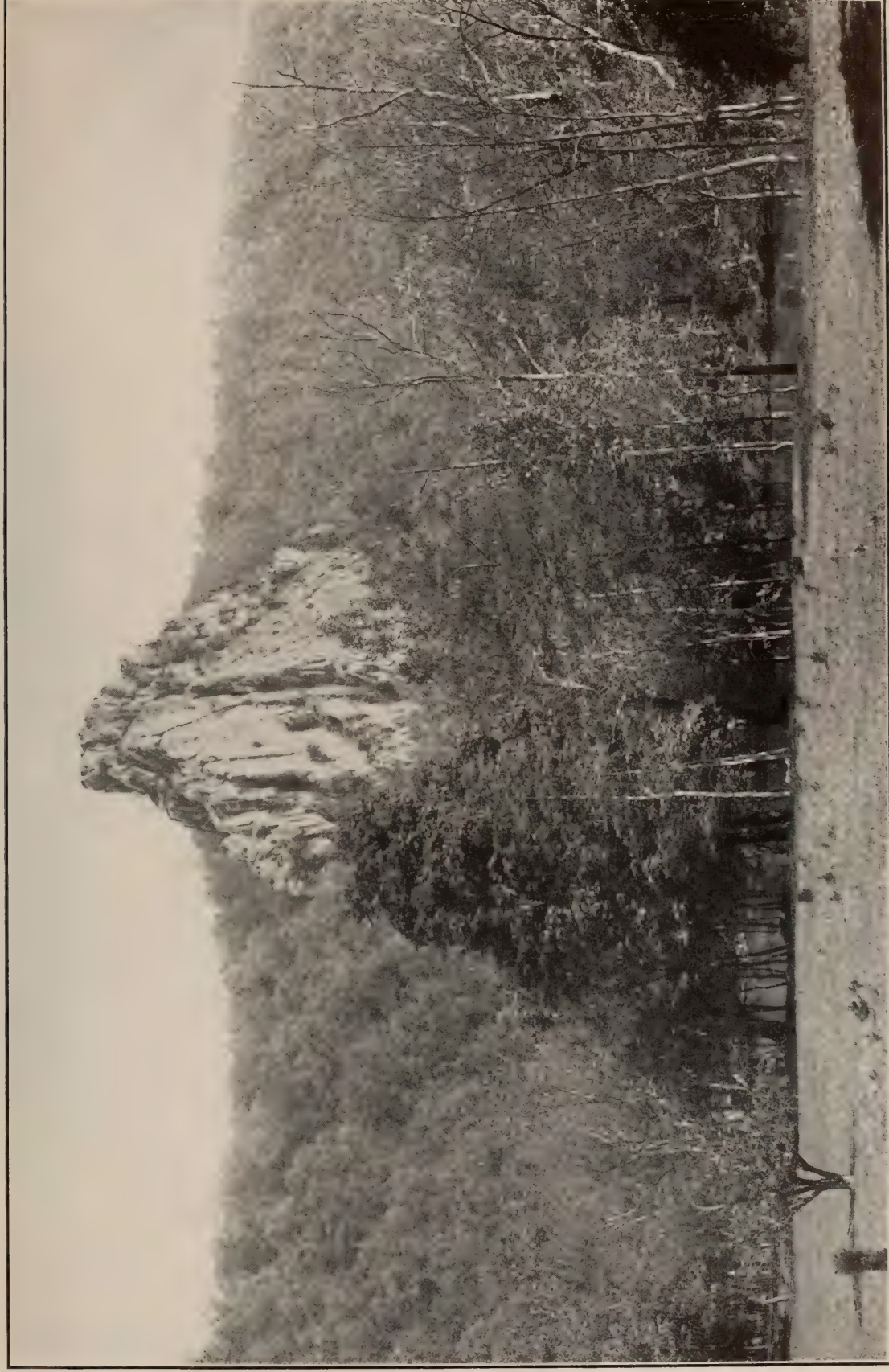
Formation.	Feet.	Description
Black shale.		Black shale containing fossils of Genesee age.
Oriskany formation (141 feet).	70	Thick-bedded hard chert, cherty sandstone, and siliceous limestone; fossiliferous.
	20	Limestone and chert, interbedded; very fossiliferous.
	10	Gray and red sandstone.
	24	Limestone and chert; fossiliferous.
	17	Gray, reddish, and greenish calcareous sandstone containing phosphate nodules and fine quartz conglomerate beds.
Rocks of Cayuga age (127 feet).	17	Thinly laminated drab limestone and sandy limestone; contains Leperditia.
	6	Irregular-bedded calcareous sandstone.
	12	Shaly siliceous limestone.
	77	Tough calcareous sandstone and sandy limestone; sparingly fossiliferous.
	10	Thick-bedded sandstone and quartzite.
	5	Thin-bedded finely conglomeratic sandstone, and thin iron ore.
Clinton formation		Red and light-gray sandstones and sandy shales.

In the Bristol area the beds of Cayuga age were apparently included with the overlying chert beds of Oriskany age in what was called Hancock limestone, whereas northeastward in Bland and Giles counties about the same assemblage of rocks was called Giles formation.

The absence of all or part of the Helderberg and Cayuga limestones or their sandstone equivalent bears a close relation to the occurrence of manganese ore deposits, and for this reason the manganese, and possibly also the iron, ores are believed by the writers to be associated with an unconformity at the base of the Oriskany. The details of the occurrence or absence of the different parts of the rocks of Cayuga and Helderberg age are but partially known in the area covered by this report, and such details are mentioned in the descriptions of the individual mines and prospects.

Oriskany formation.

The Oriskany is apparently well represented across the State, but varies in thickness and character from place to place. In general it is thickest



Caudy's Castle, near Forks of Cacapon, Hampshire County, W. Va.

(By courtesy of W. H. Wyand.)



on the northwest side of the belt here described and in adjacent parts of West Virginia, and it thins southeastward, being absent or represented by only a thin iron-ore bed in some of the most southeasterly outcrops of its horizon. As it is the chief formation with which the manganese ore of this region is associated, its character and thickness at various places will be described in some detail.

In Morgan and Berkeley counties, W. Va., and extending into the adjacent part of Frederick County, Va., the Oriskany sandstone is generally 200 feet thick, but varies from a minimum of 100 to a maximum of over 400 feet. In the Warm Springs Ridge near Berkeley Springs it is a fine even-grained white friable sandstone, 130 feet of which is quarried for glass sand. At most places it is not so uniform in character or so pure a quartz sand. It generally has a coarse granular impure bed at the top, composed either of dark glassy quartz fragments in a dark dirty matrix, or of rounded pea-size milky quartz pebbles closely packed but loosely cemented. The massive even-grained beds are generally fossiliferous, the fossils being calcareous and occur as large empty molds on weathered surfaces. In some places the formation is so calcareous that it is bluish and is burned for lime. Because of its calcareous or loosely cemented character it is not very resistant to weathering here and makes hills or ridges of only moderate height.

In Hampshire County, W. Va., and western part of Frederick County, Va., the thick beds of Oriskany sandstone are so resistant that they make some of the highest mountains and are exposed in sheer cliffs 500 feet high. (See Plates VII and VIII.)

In southwestern Frederick County, 60 feet of Oriskany sandstone was observed in a small stream gap in the sandstone ridge at the old Bean Furnace. A coarse 6-foot bed forms a ledge at the top of the section and another bed about 6 feet thick pitted with fossil molds forms a ledge at the base. On Manganese Ridge, also in southwestern Frederick County, and on Godlove Hill and Bonnet Hill, in the adjacent part of Shenandoah County, the Oriskany has a maximum thickness of 100 feet. In southwestern Shenandoah County the Oriskany sandstone is 25 to 30 feet thick and sufficiently resistant to make prominent sandstone ridges. To the eastward in Massanutten Mountain in Shenandoah County the Oriskany thins to about 20 feet and is composed of massive-bedded coarse sandstone and quartz-pebble conglomerate. There it is underlain by a manganese-ore bed 10 to 20 feet thick composed of fragments of sandstone and yellow clay,

forming a coarse breccia, and this rests on fine-grained gray sandstone of apparently Cayuga age. The ore bed may represent limestones of Helderberg age.

In Highland County and western Bath County the Oriskany is 150 to 200 feet thick and is composed of uniform buff sandstone which makes low hills. Southeastward in Augusta and in parts of Bath and Rockingham counties the sandstone is not over 25 feet thick and in places is represented only by a deposit of iron ore at the unconformable contact with the underlying limestone of Helderberg age.

In Alleghany County and western Botetourt County about 50 feet of Oriskany sandstone is nearly everywhere underlain by a zone 20 to 60 feet thick of soft sandy clay and pure white siliceous clay, probably originally calcareous, which generally is iron-bearing and rests on thick-bedded chert of Helderberg age. It is in this ore zone that the noted deposits of Oriskany iron ore of the Rich Patch, Low Moor, Glen Wilton, Oriskany, Lignite, and other mines in the vicinity of Covington and Clifton Forge are located. At Eagle Rock gap, on the James, about 200 feet of sandstone of Oriskany age is underlain by more than 130 feet of sandstone of presumably Cayuga age, the chert of Helderberg age apparently being absent. (See section on p. 31.) At the Fenwick mine on Mill Creek, northeast of Newcastle, the sandstone of Oriskany age is soft, thin bedded, and only 50 feet thick, and overlies 10 to 12 feet of ore-bearing yellow and white clay of Oriskany or Helderberg age. The ore beds rest on chert of uppermost Helderberg age. The Oriskany is overlain by Devonian black shale. In Craig County, south of Newcastle, there appears to be about 100 feet of Oriskany sandstone, composed mostly of soft, crumbly sandstone capped by a heavier bed and having a coarser sandstone at its base. The underlying limestones contain fossils of apparently lower Oriskany age.

In western Giles County a massive bed of coarse sandstone 20 to 30 feet thick, which is apparently all that represents the Oriskany there, makes rocky foothills of Peters and Fork mountains. South of New River in Giles County chert composes much of the upper part of the Oriskany. About 30 feet of sandstone, the lower part of which is a coarse cross-bedded pebbly bed carrying characteristic Oriskany fossils, is overlain by 50 to 75 feet of softer sandy beds, and this is capped by about 30 feet of interbedded chert and sandy shale. In eastern Bland County the formation consists of 20 feet of coarse sandstone, carrying small quartz pebbles and impregnated with iron oxide, overlain by 30 to 40 feet of cherty beds. Above this there is in places a yellow to green fossiliferous sandstone con-

taining limestone pebbles, which apparently is younger than Oriskany and does not belong in the formation. In most places the chert is overlain by fissile black shale of Genesee age. The slopes of Flat Top and Round mountains, which are composed largely of Oriskany sandstone, are covered with fragments of the upper cherty beds of the formation. Oriskany sandstone also forms the crest of foothills on the flanks of East River, Rich, and Elk Garden mountains in Bland and Tazewell counties and their outer slopes are likewise covered with chert debris. In places the formation rests on limestone of Helderberg age but in most places in this region it overlies sandstones and impure thinly laminated limestones of Cayuga age. Excellent exposures of the formation occur in the vicinity of Rocky Gap, Bland County, where the formation has a thickness of about 100 feet, of which 50 feet is chert. The lower sandstone contains greensand, phosphatic nodules, manganese oxides, rounded quartz grains, and other evidences of shallow water or terrestrial origin. The section is as follows:

Composite section of rocks in vicinity of Rocky Gap, Bland Co.

Formation.	Feet.	Feet.	Character of rocks.
Oriskany formation.	97	15	Crumbly sandstone.
		52	Irregular-bedded chert containing thin layers of green-sand, wad, round glassy quartz grains, and phosphatic nodules.
		30	Buff to white sandstone containing rounded glassy quartz grains; soft and crumbly above, laminated and cavernous weathering below.
Rocks of Cayuga age.	56	18	Red even-grained sandstone, green and yellow blotches.
		10	Gray and green fissile shale and thin red sandstone.
		25	Greenish thick-bedded sandstone, shaly below.
		3	Hard pyritic thin-bedded sandstone, pyritic conglomerate of white quartz pebbles at top.
Keefer (?) sandstone member.		5	Thick cross-bedded hard gray quartzite.
		4	Sandstone and gray and black shale.
		6	Massive white to light-gray quartzite, containing Scolithus tubes.
Clinton formation.	282	5	Thick red sandstone; ferruginous and pyritic at base.
		15	Interbedded gray and black fissile shale and thin platy quartzite with glassy quartz grains and surface markings on bedding planes.
		47	Red ferruginous sandstone mostly massive, but some thin bedded and shaly.
		15	Shaly sandstone.
		5	Hard red sandstone.
		55	Covered.
		50	Rusty shale and thin irregular rusty sandstone beds.
		45	Greenish gray thick-bedded sandstone with thin shaly partings, 5 feet apart.
		15	Thin-bedded hard sandstone; surface markings on bedding planes.
		15	Covered.
Clinch sandstone.	50	20	Grayish massive-bedded sandstone.
		30	White quartzite, thin bedded above, massive below.
			Red and gray to yellow mottled, banded sandstone and shale.

Detailed section of Oriskany formation half a mile northwest of Rocky Gap.

Feet.	
15	Gray, yellow, and red crumbly sandstone.
15	Irregular thin beds of chert; some yellow sandy clay beds containing chert fragments (derived from cherty limestone) near top.
7	Irregular thin beds of chert with 3 layers 4 to 6 inches each of crumbly greensand.
15	Irregular-bedded massive chert with few thin seams of shaly greensand. (See Pl. VI.)

Feet.	
2	Chert with thin seam of wad at top.
1½	Greensand with rounded cherty phosphate nodules and wad.
12	Yellow sandy clay containing thin chert layers (derived from thick cherty limestone), thin seams up to 6 inches, of wad, and thin bed of red-stained sandstone composed of greensand and rounded glassy quartz grains.
30	Buff to white sandstone containing rounded glassy quartz grains in alternating hard and crumbly layers 2 to 3 inches thick. Softer layers 1 foot thick stained with manganese oxide.
97½	

On the southeast flank of Clinch Mountain in Smyth, Washington, Scott, and Russell counties and southwestern Tazewell County, the Oriskany is largely massive chert, which in freshly cut stream exposures, is seen to be a hard cherty limestone. In some places a greenish phosphatic sandstone occurs at its base. It varies from a maximum of 200 feet to a few feet in thickness, and in some places it is apparently represented only by siliceous iron ore. On Walker Mountain, which lies some distance to the southeast of Clinch Mountain, out in the valley, white chert of Oriskany age about 10 feet thick locally rests on red sandy shales of Maysville age, the beds of Medina, Clinton, Cayuga, and Helderberg age, which normally intervene, being absent.

Romney, Jennings, and Hampshire formations.

Overlying the Oriskany formation are dark shales and sandstones comprising the Romney, Jennings, and Hampshire formations, of Devonian age. The Romney shale in the northern part of the State is composed of dark fissile carbonaceous shales of Marcellus (and in places Onondaga) age at the base, and dark-gray hackly to blocky weathering shales, with some sandstones, of Hamilton age above. In Berkeley County, W. Va., and the northeastern part of Frederick County, Va., the lower fissile shales are about 300 feet thick and the upper hackly shales of Hamilton age are about 1,200 feet thick. At Romney, W. Va., the type locality, a finely fissile black shale at the base contains minute flattened thin-shelled fossils, and in this respect closely resemble the higher shale of Genesee age. The Romney shale is known to be present in Frederick and Shenandoah counties and is reported to be present and to contain Onondaga, Marcellus, and Hamilton fossils in Highland and Bath counties. It is absent at all places visited by the writers in the southwestern counties of the State as far northeast as Bland County, the shale formerly called Romney in that

area having been proved to be of Genesee and Portage age, and is also believed to be absent in Giles and Craig counties. At one place, however, near Big Stone Gap, a thin layer, an inch or two in thickness, of much disturbed and rusty black shale containing Hamilton fossils was found at the base of the Genesee, showing that some Romney was deposited there and largely removed by erosion. Similar Hamilton or Marcellus fossils were found in thin basal black shales at Mendota.

The Romney is succeeded in Berkeley County, W. Va., and northeastern Frederick County, Va., by the Jennings formation, which is composed of thin black fissile shale of Genesee age at the base, olive to drab fissile shale and thin very fine-grained compact sandstones of Portage age in the middle, and sandy, gray to rusty shales and gritty, green to gray sandstones of Chemung age above. These pass upward into red sandstones and shales of Catskill age, which comprise the Hampshire formation. The lower fissile shales of Genesee and Portage age are there about 2,000 feet thick, and the sandy beds of Chemung and Catskill age are about 2,800 feet thick. The various divisions of the Jennings extend southwestward nearly across the State, and overlap the Romney in that direction, so that in Tazewell County and southwestward, where the Romney is generally missing, the black fissile shale of Genesee age rests on chert of Oriskany or Helderberg age. In Bland County about 400 feet of black fissile shale, called Romney in the geologic folios,¹ is largely of Genesee and lower Portage age, and therefore younger than the Romney shale, and the overlying 3,000 feet of greenish to gray fissile shales passing upward into sandstones, called Kimberling shale in the geologic folios, is of Portage and Chemung age, possibly including a representative of the Catskill at the top. In the Bristol area the black fissile shale of Genesee age has (erroneously in the author's opinion) been called Chattanooga in the geologic folio,² on the supposition that it is the representative of the Chattanooga shale of Tennessee, and the overlying shale of Portage, Chemung, and Mississippian age is called Grainger. Farther southwest, in the Big Stone Gap area, rocks of Chemung age are absent, and shale of Genesee and probably Portage age and overlying black shale, regarded by E. O. Ulrich as in part of Sunbury age, have been together called Chattanooga shale. The name Grainger shale has been applied to higher rocks of Cuyahoga age, probably in part equivalent to the Price sandstone.

¹ U. S. Geological Survey Pocahontas and Tazewell folios of the Geologic Atlas.

² U. S. Geol. Survey Bristol folio of the Geologic Atlas.



(A) Inclined strata on Marion & Rye Valley Railroad near Quebec, Va.



(B) Broad anticlinal fold. Hanging Rock, Hampshire County, W. Va.

(By courtesy of H. B. Brockett, Jr.)

Lower Mississippian sandstone and overlying Carboniferous rocks.

Overlying the Devonian shales and sandstones in most places in Virginia is a granular bluish-white sandstone containing in places scattered quartz pebbles, which is of early Mississippian age. It is called Pocono sandstone in northern Virginia and Price sandstone in Bland and Tazewell counties. Farther southwest it loses its distinctive sandy character and has been included in the Grainger formation, and in the Big Stone Gap area it comprises practically all of the Grainger.

This sandstone is overlain in places in southwestern Virginia by shale that carries salt and gypsum, called Maccrady formation, but in most places it is succeeded by limestones and limy shales called Newman limestone in the southwestern part of the State and Greenbrier in the northwestern part. Shales and sandstones of Mississippian age overlie the limestone. These and higher rocks of Pennsylvanian age are grouped together on the accompanying geologic map (Plate IV) as they are not related to the problem discussed in this paper.

STRUCTURE.

The sedimentary rock layers of this region have been extensively folded, the folds having their elongated axes parallel and trending northeastward. Erosion has worn off many of the upper layers of rock, so that their severed edges now appear at the surface in narrow nearly parallel belts which also strike northeastward. The layers of hard rocks, such as sandstone and quartzite, resisted erosion, whereas the soft and soluble rocks, like shale and limestone, have been deeply eroded, and form valleys between ridges and mountains of the harder rocks. These generally trend northeastward, being controlled by the rock structure, and form the belt of valleys and ridges which occupies the western side of the Appalachian Valley of Virginia. (See Pl. I.)

The folds, although extending for many miles, rise and fall, and at their ends generally pitch sharply, their places being taken by other folds on either side. Upfolds or arched strata are called anticlines; downfolds or troughed strata, are called synclines. Generally only one side of a fold is seen in an outcrop, the rock layers dipping in one direction, either into a syncline or away from an anticline. (See Pl. VIII, A.) Only where the rocks pitch or rise at the end of a fold are larger synclines and anticlines recognizable by the looping of the ridges around the end of the fold, but innumerable smaller folds within the larger ones may be seen in outcrops,

especially where streams have cut through such folded rocks. (See Pl. VIII, B.) Where a hard bed forms the end of a rising syncline or plunging anticline the resistance of the bed to erosion is increased, and the resulting mountain is apt to be either higher or more massive than where the bed is single.

The folding is most intense on the southeastern side of the Appalachian Valley and is progressively less intense northwestward. The closest folding therefore is in the limestones and associated shales of Ordovician and Cambrian age, which form the open southeastern part of the valley. These folds do not generally have so marked effect on the topography as do those in the northwestern part of the Valley because of the absence of hard beds at the surface to make ridges, but Massanutten Mountain is an exception. This mountain is produced by a synclinal fold of such unusual depth that the hard Tuscarora sandstone, which overlies the softer rocks, was brought so low that it was here protected from complete removal by the erosion which removed it from the rest of the region. So these hard beds form an outlying mountain in the open valley. (See Pl. II, B.) The folds northwest of the open valley are more noticeable because they are deep enough to contain the Tuscarora or Clinch sandstone and higher beds, which make alternate ridges and valleys. In the northern part of the State few of the synclines in the Appalachian Valley are deep enough to inclose the Carboniferous strata because the Devonian and Silurian rocks there are very thick. In southwestern Rockingham and adjacent part of Augusta counties, where the Carboniferous is preserved in a deep syncline, its hard beds make Elliott Knob and other high peaks which tower far above the adjacent mountains. Anticlines that bring the Ordovician limestone high enough to form limestone valleys are equally uncommon in this part of the State. One of the largest Ordovician limestone valleys exposed in an anticline is at Hot Springs, and smaller ones occur southwest and southeast of Covington. (See Plate IV.)

Another long narrow synclinal infold of Carboniferous rocks lies southwest of Fincastle and extending southwestward nearly as far as Marion, its hard rocks forming Little Walker Mountain much of the distance. Opposite the point where this syncline shallows and the Carboniferous ends another long synclinal fold to the west deepens and incloses Carboniferous rocks which extend southwestward to the south boundary of the State. These rocks are however relatively soft and do not form such high mountains as do the Carboniferous sandstones to the north. The rocks which intervene between the Ordovician limestone and the Carboniferous are

much thinner in this part of the State and most of the upfolds therefore bring the Ordovician limestone to the surface, giving rise to wide areas of rolling blue-grass country northwest of Clinch Mountain, as far northeast as Tazewell.

The Appalachian Plateau enters southwestern Virginia and its steep front marks the eroded edge of the Pennsylvanian sandstones which underlie the coal measures to the northwest. These beds are but gently tilted northwestward, except around the Big Stone Gap embayment where the folding is locally intensified by the high anticline which plunges northeastward behind Powell Mountain.

Many of the folds in the Appalachian Valley are so tightly compressed that the beds have broken and the rocks on the southeast side have been pushed over those on the northwest along what is called a thrust fault. Although some faults of considerable horizontal displacement occur within the valley ridges, particularly one at the southeast foot of the Appalachian Plateau escarpment in Wise, Russell, and Tazewell counties, the greatest faults occur in the limestone valley or within the adjacent Appalachian Mountains. A major fault which enters the State from the north lies within the Blue Ridge or at its western foot as far south as Roanoke. Here it enters the open valley of the Valley of Virginia, which is narrow at this point, crosses to its western side, and then follows the southeast foot of the first range of the Valley Ridges southwestward, where Ordovician and Cambrian limestones are faulted against Carboniferous rocks. (See Pl. IV.) The fault plane, which was originally nearly horizontal, has itself been strongly folded by later warping of the rocks, and in places the overthrust rocks have been eroded from the upfolds and mountains of younger over-ridden rocks now appear through breaks, or "fensters," in the overthrust rocks. Draper Mountain is such a mountain of younger overriden rocks rising from a plain of overthrust older limestone. Many of the intricate relations along this part of the fault have not yet been traced out. Southwestward the fault cuts off the rocks that form Little Walker Mountain and, still farther southwest, those that form Walker Mountain, thus terminating these ridges in that direction.

The structure of the rocks affects the deposition of ore by directing the movement of circulating water within the rocks. Descending waters tend to follow the bottoms of synclines and rising waters tend to follow the crests of anticlines. Structure appears to have been a controlling influence in the deposition of manganese ore in the Shady dolomite on the east side

of the Valley, because the quartzite underlying the Shady is relatively impervious and the circulating mineralized waters were in places concentrated in synclines. The deposits in the Knox dolomite and in the Oriskany formation and associated rocks in western Virginia do not seem to have been much influenced by structure as there are no controlling impervious beds closely associated with the ore-bearing horizons. Nevertheless the large deposits in the Stange and Suiter mines are at the crest of anticlines and the higher-grade deposit of the Powells Fort mine is in a syncline.

ORE DEPOSITS

LOCATION.

The manganese ore deposits in western Virginia are widely distributed, occurring at numerous localities from the northern to the southwestern part of the State. The known deposits are in Frederick, Shenandoah, Bath, Alleghany, Botetourt, Craig, Montgomery, Giles, Bland, Tazewell, Russell, Washington, Scott, and Wise counties. The deposits that have produced the bulk of the ore from this part of the State are in Frederick, Shenandoah, Craig, Giles, and Bland counties.

The belts of formations with which the ores are associated are shown on the geologic map (Plate IV, in the pocket) and the location of the mines and most of the prospects is shown on larger scale maps which form figures in the chapter on Mines and Prospects.

HISTORY, PRODUCTION, AND USES OF MANGANESE ORES.

The manganese deposits of western Virginia have been worked at times since 1834 and have yielded both manganese and manganiferous iron ores. The earliest mine to be worked was the Mineral Ridge mine in Frederick County. It is said to have been worked for many years before the Civil War, beginning in 1834, and for many years after the war, and the total production of this mine during the period ending in 1885 is reported to have been about 2,000 tons. Among the early operators were William Remsen, Jos. W. Patterson, and Josiah L. Woodward. The Bonnet Hill mine in Shenandoah County was worked in 1848 by William Remsen but no ore from it was marketed at that time. The Godlove mine in Shenandoah County was first worked about 75 years ago by Joel Williams, who marketed considerable ore, and it was again worked by Cline and Capon 35 to 40 years ago and by Scott Roach about 30 years ago, though they did not market any ore. The Capola Mountain mine was worked extensively many years ago, large amounts of manganese ore being shipped before the Civil War. The Powells Fort mine was opened in 1880 but at that time was not worked for any considerable length of time. It was next worked in 1907 and 1908. The Cook mine in Botetourt County was opened in 1911.

During the period from 1915 to November, 1918, when there was a great demand for domestic manganese ores for which high prices were

paid, manganese mining in western Virginia, as elsewhere in the United States, was greatly stimulated. Most of the above-mentioned mines and also others were reopened, new mines—notably, the Stange mine in Giles and Bland counties, the Suiter mine in Bland County, and the Chevy mine in Craig County—were opened, and numerous new localities were prospected for manganese ore. In November, 1918, when the armistice with Germany was signed, the demand for domestic ores practically ceased, except for the filling of unexpired war-time contracts, and work at most of the mines and prospects stopped. The only mines in western Virginia that have been operated since that date are the Mineral Ridge, Godlove, Bonnet Hill, and Stange mines.

The production of the different grades of manganese ore in western Virginia from 1915 to 1920 inclusive is given in the accompanying table.

Production of manganese ore in western Virginia, 1915-1919.¹

Year.	Manganese more than 35 per cent. (Long tons.)	Manganese 10 to 35 per cent. (Long tons.)	Manganese 5 to 10 per cent. (Long tons.)
1915	176	None	None
1916	160	None	None
1917	5,048	None	400
1918	5,050	339	None
1919	1,720	None	None
1920	525	None	None
	12,679	339	400

The mines that have produced the bulk of the ore from western Virginia and the total amount of the output of each, are as follows: Mineral Ridge mine, about 4,000 tons; Capola Mountain mine, production considerable but not known; Powells Fort mine, at least 2,400 tons; Stange mine, about 2,000 tons; and Suiter mine, about 6,000 tons.

The ore from most of the mines in western Virginia has been used in making ferromanganese, spiegeleisen, and high-manganese pig iron. All of the ore from the Powells Fort and Godlove mines and much of that from the Bonnet Hill and Mineral Ridge mines has been used for chemical purposes and for making bricks. A large proportion of the ore at the Stange mine is pyrolusite which is apparently suitable for chemical purposes and

¹ Compiled from statistics that were furnished by the mine operators to the United States Geological Survey.



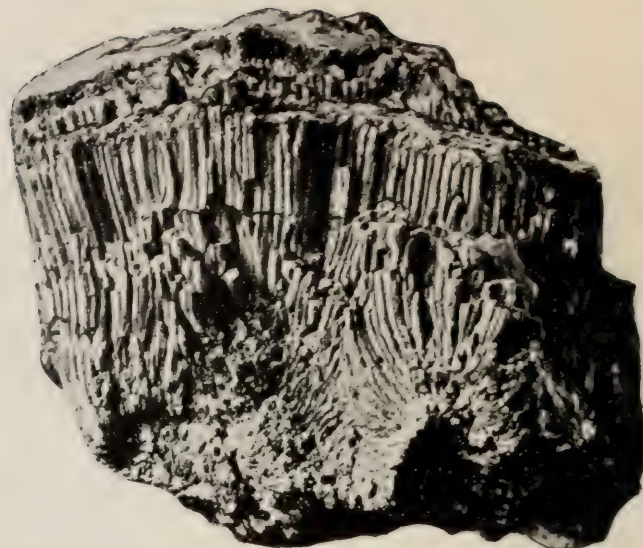
(A) Pendant-like botryoidal forms of psilomelane. Mineral Ridge mine, Frederick County.



(B) Peculiar noded form of turreted psilomelane nodule. Stowe mine, Bland County.



(A) Radiate rodlike or tubular psilomelane embedded in massive botryoidal psilomelane. Donahue prospect, Bland County.



(B) Parallel rodlike psilomelane. West Suiter mine, Bland County.



(C) Detached globules of psilomelane in a matrix of crystalline pyrolusite. Powells Fort mine, Shenandoah County.

if this mine is reopened, at least a part of its production will probably be chemical ore. The ore for chemical purposes has been used in dry batteries and in the manufacture of flint glass. For dry batteries, ore which contains a high per cent (usually 80) of manganese dioxide (MnO_2) is essential, as its usefulness for this purpose depends largely on its oxidizing properties. It must also be nearly free from iron (less than 1 per cent), copper, and certain other elements.

MINERALS OF THE ORES.

The manganese minerals present in this area are all oxides. They closely resemble iron oxide and they are frequently mistaken for one another. A simple way to distinguish manganese oxides from iron oxides in the field is to scratch a piece of white chert or quartzite with the mineral to determine its real color or streak. Manganese oxide makes a very dark brown to black streak. Iron oxide in the form of hematite makes a reddish-brown streak, and, in the form of limonite, a yellowish-brown streak, although the surface of both limonite and hematite may be shiny and jet black. Iron ore containing some manganese makes a brownish-black streak.

The manganese oxide bearing ores of the eastern United States are classed in three general groups—manganese ores, ferruginous manganese ores, and manganiferous iron ores. All of these occur in western Virginia. The manganese ores in this region are all oxides, four minerals being commonly present—psilomelane, wad, pyrolusite, and manganite.

Psilomelane.—Psilomelane is the commonest manganese mineral in the Appalachian deposits. It is black or steel blue, amorphous, and dense, and has a conchoidal fracture. Its luster is submetallic and its streak brownish black. It usually has a concentric and somewhat radiate structure and rounded mammillary or botryoidal surfaces. This rounded form is due to the tendency of the mineral to grow by concentric accretion. It also tends to grow in a plumose or dendritic form, and in consequence the rounded forms are at times elongated, some being arranged in clusters like bunches of grapes. (See Pl. IX.) Some psilomelane occurs as parallel and radiate rods. (See Pl. X.) The nodules are generally more or less isolated, and may be attached to one another by only a small projection or stem. Where the solution which deposited the manganese minerals came more freely along a joint or crevice in the rock, the botryoidal forms grew into the wall rock perpendicular to the crevice and are attached at their base to a plate of ore which formed in the crevice. None

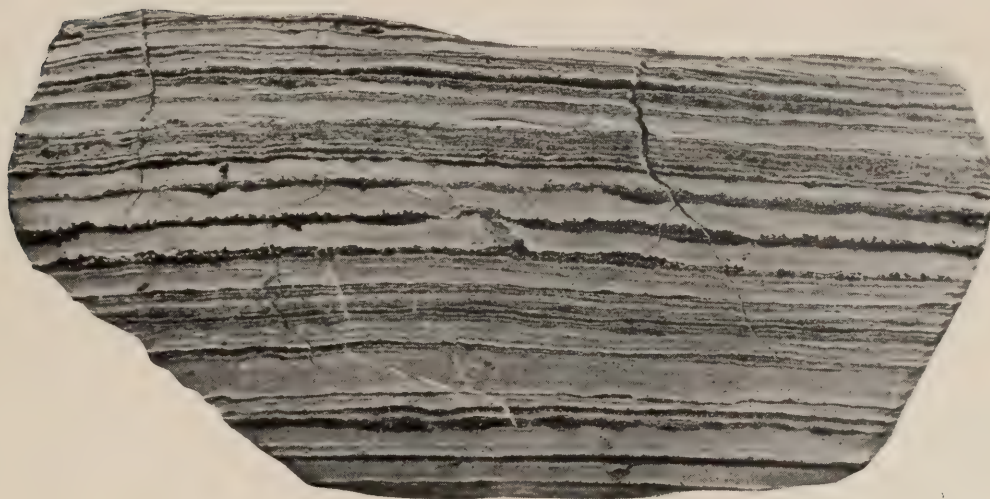
of these odd shapes have developed in open spaces but have been formed in clay, sandstone, or other rock, where they grew by the gradual replacement or absorption of the inclosing material. (See Pl. XI.) Where the manganese solution permeated the whole rock the ore may be banded by the absorption of impurities in certain layers, and the nodular forms may be turreted. (See Pl. XI.)

Psilomelane has a hardness of 5 to 6.5, which means that a knife blade scratches it with difficulty if at all. Some specimens of psilomelane that can be slightly scratched are probably either impure or weathered. The mineral is heavy, its specific gravity being 3.7 to 4.7. Although its composition is complex, being represented by the formulas $\text{MnO}_2 \cdot (\text{Mn}, \text{K}, \text{Ba}) \text{O} \cdot n\text{H}_2\text{O}$ and H_4MnO_5 , it is not definite. It always contains water, the quantity of which varies from 2.5 to 6 per cent, and it generally contains considerable barium and some potassium, 17 per cent of barium and 5 per cent of potassium being the maximum recorded in analyses of the mineral. These two elements are believed by some to be mechanically admixed and by others to be chemically combined with the manganese and other elements. The percentage of manganese varies from 50 to 57. Some nodules are composed of two or more varieties of the mineral, the original mineral composing the nodule having shrunk, probably by loss of some of its water, and cracks which formed in the interior of the nodules have been filled with a similar mineral of somewhat greater hardness and finer texture. Such nodules closely resemble calcareous septaria. (See Pl. XII.)

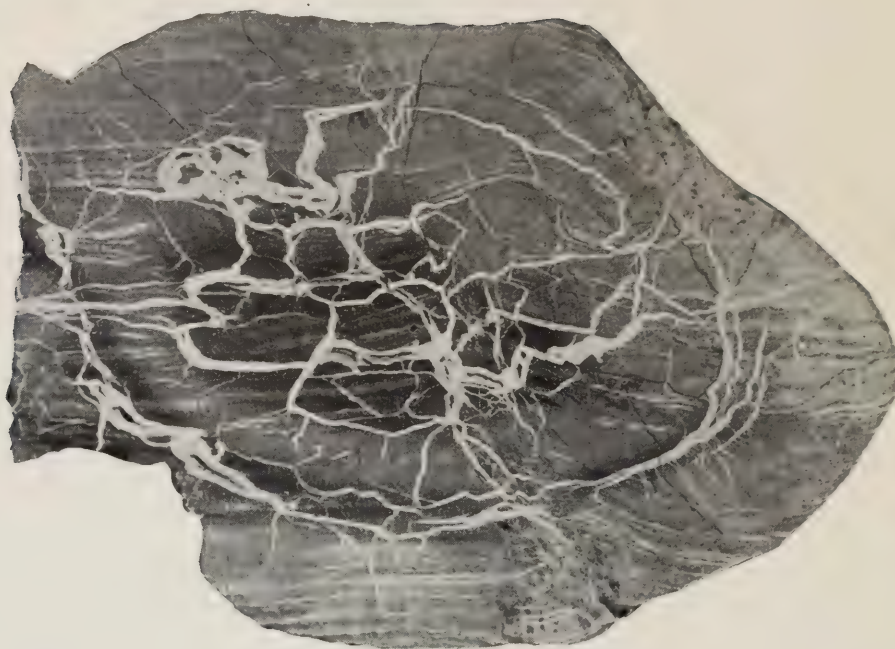
Manganite.—Manganite ($\text{Mn}_2\text{O}_3 \cdot \text{H}_2\text{O}$) is a heavy, grayish-black to black, generally crystalline mineral. It has a hardness of 4 (moderately hard, cannot be scratched with a brass pin), and a specific gravity of 4.2 to 4.4. On fresh fracture it is grayish-black, and its streak is dark reddish brown or nearly black. It crystallizes in druses in orthorhombic form, the crystals generally having a bladed or wedge shape, similar to those of pyrolusite. (See Pl. XIV.) The crystal faces are black and have a brilliant metallic luster, but may be tarnished to a brassy color. It also forms spherical masses of "needle ore" which, when broken, shown glistening needle-like crystals arranged radially. (See Pl. XIII.) In other "needle ore" the fibrous crystals are parallel and are more than $2\frac{1}{2}$ inches long. The mineral contains theoretically 62.4 per cent manganese and 10.3 per cent water. It is frequently associated with psilomelane in the Appalachian deposits, generally lining small cavities in psilomelane. In some



(A) Turreted psilomelane in which the original lamination of the rock by impurities is preserved in the ore. Stowe mine, Bland County.



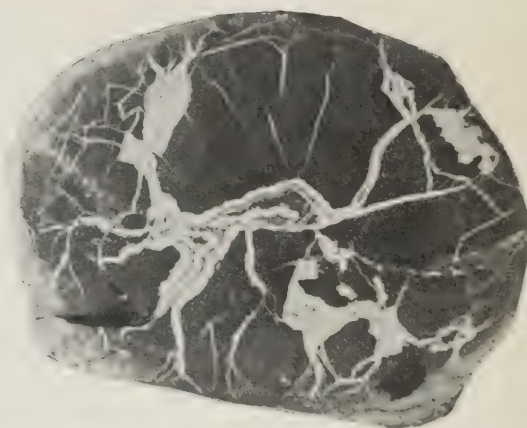
(B) Polished face of psilomelane showing banding due to impurities in the rock which were replaced by ore. Red Brush prospect, Craig County.



(A) Polished section of a nodule of psilomelane, showing irregular radial and concentric shrinkage cracks which have been filled by the deposition of harder, dense psilomelane. Red Brush prospect, Craig County.



(B) Side view of turretted nodule of psilomelane from the Stowe mine, Bland County, shown in section in (C).



(C) Polished cross section of turretted psilomelane nodule, showing irregular shrinkage cracks filled with purer psilomelane. Stowe mine, Bland County.

ores these two minerals are concentrically deposited in minute laminae. (See Pl. XIII.) The presence of manganite is generally regarded as an indication of high-grade ore.

Pyrolusite.—Pyrolusite (MnO_2 generally with a little H_2O) is a grayish-black to steel-gray mineral with crystalline or granular structure. It is decidedly soft, having a hardness of 2 to 2.5 (can be scratched by the finger nail and readily soils the finger), and a specific gravity of 4.8. Its color on fresh fracture is steel-gray as distinct from the grayish-black or black of manganite. Its luster is generally metallic and its streak black. It crystallizes generally in bladed or wedge-shaped crystals of orthorhombic form (see Pl. XIV) which are black and have a brilliant metallic luster, sometimes tarnished a brassy color. It sometimes crystallizes in plumose forms. (See Pl. XIII.) Pyrolusite is the dioxide of manganese and contains theoretically 63.2 per cent manganese. It is generally believed that in most cases pyrolusite was derived from manganite by oxidation and loss of water, retaining the latter's crystalline form or fibrous radiate structure. However, from recent studies of crystalline pyrolusite from the Powells Fort mine in Shenandoah County (see Pl. XIV), Watson¹ has concluded that the mineral from that locality was originally pyrolusite and is not pseudomorphous after manganite. Two analyses of pyrolusite from that mine are given below.

*Analyses of pyrolusite from the Powell's Fort mine.*²

[S. D. Gooch, analyst.]

	1	2
Manganese dioxide (MnO_2)	94.30	95.22
Manganese protoxide (MnO)	2.25	1.31
Ferric oxide (Fe_2O_3)	.22	.17
Alumina (Al_2O_3)	.14	.18
Baryta (BaO)	.33	.40
Lime (CaO)	.08	.11
Silica (SiO_2)	.64	.63
Phosphorus pentoxide (P_2O_5)	.52	.58
H_2O —	.22	.16
H_2O +	1.53	1.46
	100.23	100.22
Metallic manganese	60.08	61.19

1. Pyrolusite crystals.

2. Crystalline fibrous pyrolusite.

¹ Watson, Thomas L., and Wherry, Edgar T., Pyrolusite from Virginia: Wash. Acad. Sci. Jour., vol. VIII, pp. 550-560, 1918.

² Idem.

Wad.—Wad is a dark, soft, earthy mineral which is an indefinite mixture of manganese oxides with water and other impurities such as clay, barium, and iron oxides. It is generally a dry, loosely coherent, brown or brownish-black powder, not sharply distinguished except by its darker color from the slightly manganiferous clay with which it is usually associated. It contains from 30 to 52 per cent of manganese and 7 to 10 per cent of water, whereas manganiferous clay carries only 5 to 10 per cent manganese. Wad generally contains considerable barium, some specimens as much as 20 per cent.

The wad at some places in western Virginia occurs as concentric layers in psilomelane, some of which has a plumose and radiate structure. (See Pl. XV.) A variety of wad, which is especially abundant at the Suiter mine, Bland County, and also occurs at the Hoffman mine, is dark brown in color and has a low specific gravity, but has a submetallic luster and radiate structure like pyrolusite. (See Pl. XV, B.) It may therefore be an alteration product of pyrolusite, which is also commonly present at both these localities. It seems more likely, however, that the crystalline pyrolusite has been formed from the amorphous wad by purification and loss of water through crystallization and by later enrichment of manganese dioxide. A partial analysis of wad from the Suiter mine is given below.

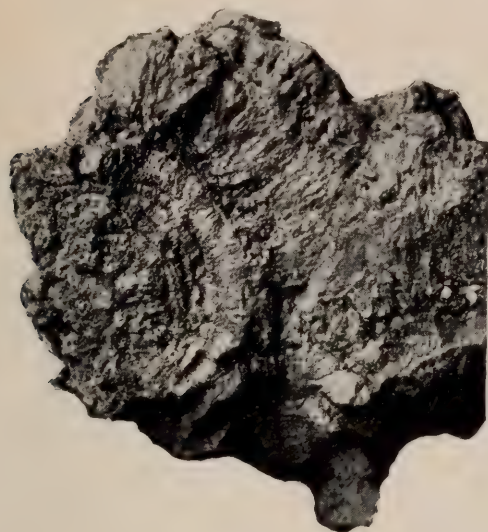
Analysis of wad from the Suiter mine.

[J. G. Fairchild, of U. S. Geological Survey, analyst.]

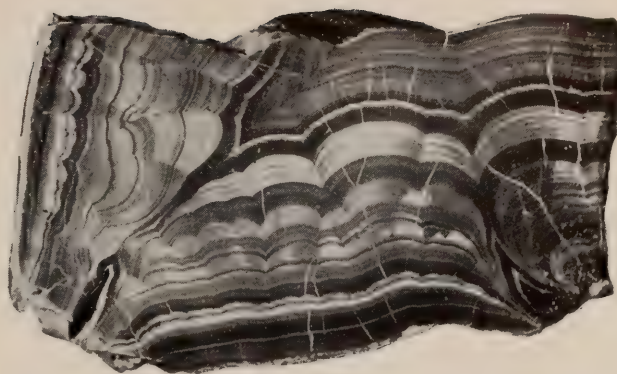
Manganese dioxide (MnO_2)	72.9
Manganese protoxide (MnO)	7.6
Baryta (BaO)	(a)
H_2O —	1.04
$\text{H}_2\text{O}+$	7.60
	89.14
Metallic manganese	51.94

(a) An appreciable amount of baryta was noted but was not determined.

Ferruginous manganese and manganiferous iron ores.—These ores of manganese and iron are mixtures of manganese oxides with iron oxides in various proportions. The iron oxide is generally limonite ($2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), or other varieties of brown ore in which the amount of water is variable. The manganese is generally psilomelane, although manganite is present in some ores. The iron and manganese oxides occur both as a mixture of the two minerals in which each is readily distinguishable in the hand specimen and as a mixture or compound in which the minerals are so intimately and



(A) Concentric layers of radiate needle manganite ore, separated by concentric bands filled with clay. Hoffman mine, Craig County.



(B) Polished surface of manganese ore, showing concentric layers of dense psilomelane and finely laminated manganite. Compton mine, Page County.



(C) Pyrolusite crystallized in plumose form in a narrow crevice in sandstone. Mineral Ridge mine, Frederick County.



(A) Wedge-shaped orthorhombic crystals of pyrolusite. Powells Fort mine, Shenandoah County.



(B) Bladed orthorhombic crystal of pyrolusite. Powells Fort mine, Shenandoah County.

minutely mixed that it is impossible to tell whether it is a mechanical mixture or a chemical combination. (See Pl. XVI.) The amount of manganese in these mixed ores varies from 1 to over 40 per cent. Iron ore that contains less than 10 per cent of manganese is called manganiferous iron ore, and ore that contains from 10 to 35 per cent manganese is called ferruginous manganese ore. The higher grades are generally used in the manufacture of spiegeleisen but in some steel plants they are mixed with higher-grade manganese ores for the manufacture of ferromanganese. The lower grades of ore down to those containing only 3 per cent of manganese are used in the manufacture of high-manganese pig iron.

TYPES OF DEPOSITS.

GENERAL FEATURES.

The workable manganese deposits of western Virginia occur in sandstone and chert—either in firm ledges or partly disintegrated—and in clays.

The ores in the sandstone and chert are fillings of crevices in breccias and are also partial or complete replacements of the sandstone and chert fragments, and are therefore generally siliceous. They generally require crushing and washing or treatment in jigs to produce a marketable product. Some ore is so intimately mixed with sand grains that, to concentrate it, it must be crushed to such fine particles that it can better be treated on tables or in dry separators.

The ores that occur in clay are mostly nodular in form, and often of very irregular and grotesque shapes. These are largely replacements of shale or argillaceous sandstone. Such ores are separated from the clay by cleansing in log washers or in trommels. They are generally of dull luster due to included clay and fine silica, which in many cases preserve the original lines of sedimentary bedding so that the surfaces of the nodules are ribbed and the broken or polished faces of the ore are banded. (See Pl. XI.)

The ore deposits of the Appalachian region, although widely distributed, are found to be associated with certain beds of rock. Those most extensively developed in the Valley of Virginia, and from which most of the ore has been mined in the Appalachians, are associated with the basal beds of the Shady dolomite. These deposits have been fully described in a previous report,¹ and will not be further referred to here. In the general

¹ Virginia Geol. Survey Bull. XVII, 1919.

search throughout the country for manganese ore during the World War, deposits were found associated with certain beds at several other horizons in the Appalachian region, but only two of these—one in the Knox dolomite and the other in the Oriskany formation and in associated rocks of either Helderberg or Cayuga age—are known to be ore-bearing in western Virginia. The ores at these two horizons represent two general types of ore occurrences and are described below.

MANGANESE DEPOSITS IN KNOX DOLOMITE.

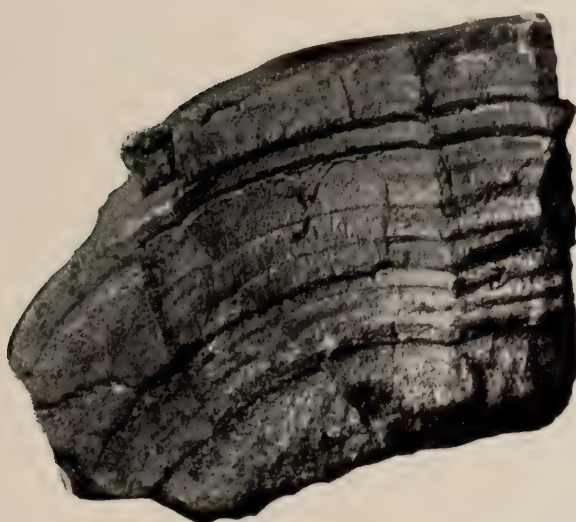
Chert in the Knox dolomite is stained black by manganese oxide at many places and is sometimes so impregnated with the oxide as to form a manganese ore. Chert masses which have been crushed and broken into small fragments are cemented together by manganese oxide and in part replaced by it, so that some masses of ore of large size are in places formed in this manner. The chert and ore were set free by the weathering of the limestone and are now found in the residual clay soil on the slopes of chert hills. Most of the ore in the chert is hard psilomelane with some crystalline pyrolusite in crevices and some of the residual masses are exceptionally pure ore. Nodular psilomelane in the form of "nut" and "grape" ore also occurs in the residual clay, having replaced chert or some of the clay. Manganese ore seems to be more commonly associated with the chert near the base of the Knox, but is not restricted to that horizon. Some deposits are in chert near fault contacts, and the concentration there is largely due to the free circulation of ground water in brecciated material near such faults.

Ore in the residual clay and chert of the Knox dolomite has been prospected and mined to some extent in Tazewell, Giles, and Craig counties. The mines and prospects in Tazewell County are chiefly around Tiptop and North Tazewell. Here most of the deposits are near the base of the formation, close to the underlying Nolichucky shale, but some are at a fault contact. In Giles and Craig counties the developments have been around Newport and Simmonsville. Those around Newport are associated with an overthrust fault, but not so those near Simmonsville. The chert-bearing limestone in Giles and Craig counties is believed to be Knox, but as the Nolichucky shale is absent there and fossils were not found in the formation, its exact age is not known. All the deposits in the Knox appear to be small and of no great value.

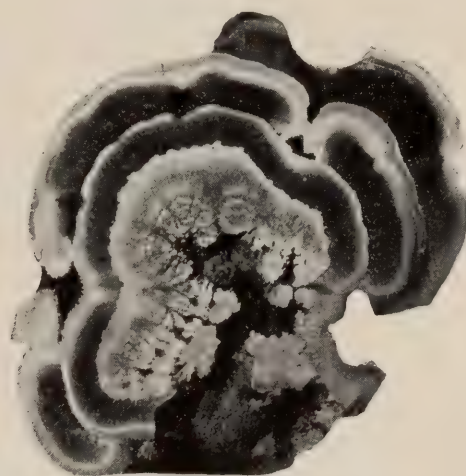
Few deposits occur in solid rock in which the ore cements brecciated chert into a solid breccia and in part replaces the chert. The ore material



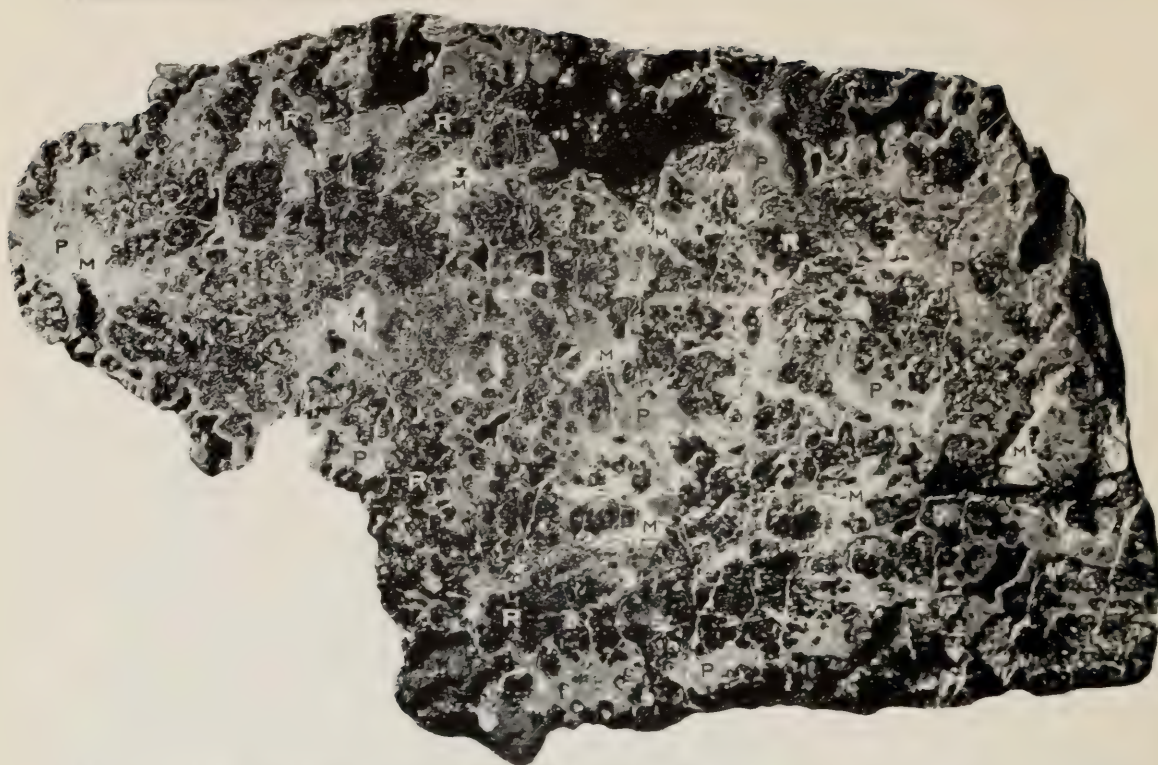
(A) Wad and possibly some manganite having radiate plumose structure, surrounded by psilomelane. Hoffman mine, Craig County.



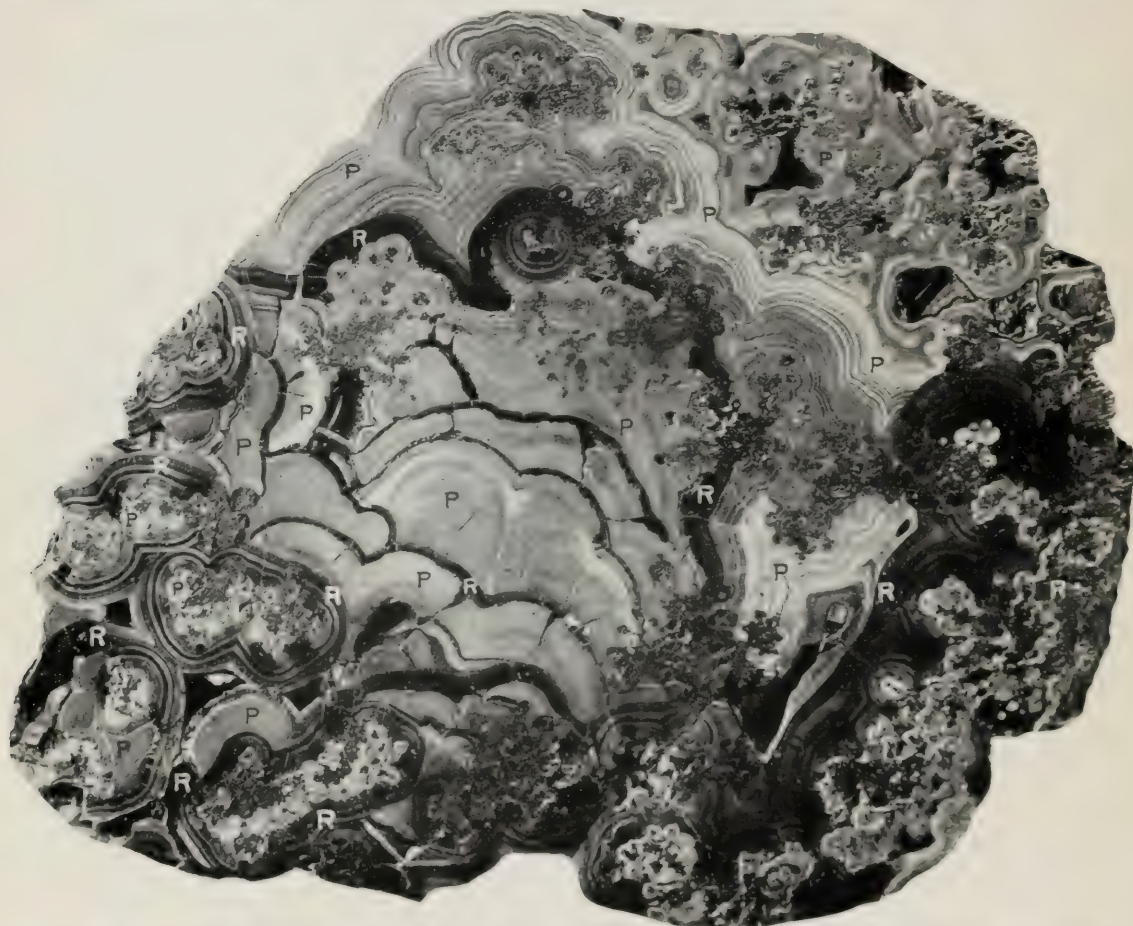
(B) Concentric layers of gray wad with submetallic luster and radiate structure. Hoffman mine, Craig County.



(C) Two concentric layers of psilomelane and wad surrounding core of manganite with radiate and concentric structure. Carrie prospect, Giles County.



(A) Polished specimen showing an intimate mixture of brown iron oxide (R), psilomelane (P), and manganite (M). Cliff prospect, Craig County.



(B) Polished specimen showing an intimate mixture of psilomelane (P) and fibrous brown iron oxide (R). Nye Cove prospect, Tazewell County.

of such deposits consists largely of fragments of fresh chert with little ore in the crevices but having pockets of various sizes of almost solid ore containing only scattered fragments of partly replaced chert. A ledge of such ore has been opened by the Pocahontas Mining Corporation near Tiptop. More commonly the ore-bearing chert has disintegrated to fragments, and loose pieces of ore and chert are scattered through residual clay derived from the weathered dolomite. This is the mode of occurrence in most of the deposits near Tiptop and at the mine and prospect at North Tazewell. In Craig and Giles counties, although fragments of chert are present in the clay, the ore occurs in the residual clay and its former association with chert, if any, is not evident.

MANGANESE DEPOSITS IN ORISKANY FORMATION AND ASSOCIATED ROCKS
OF HELDERBERG OR CAYUGA AGE.

In many places in western Virginia the Oriskany formation and its immediately underlying rocks contain deposits of manganese ore. Thin black films of manganese oxide are common on the bedding and joint planes of the Oriskany nearly everywhere, and in favorable places the oxide cements together and in part replaces the fragments of the basal beds of sandstone where they are brecciated. The next underlying rocks of Helderberg and Cayuga age, especially if they are sandstone or chert, similarly contain manganese oxide in their upper parts when conditions are favorable. The Oriskany rests normally upon chert and limestone of Helderberg age, but at many places in Virginia these beds are absent so that it rests unconformably on rocks of Cayuga age, which are chiefly sandstones and thinly laminated limestones.

In Bland and Giles counties of southwestern Virginia, sandstones of Oriskany age and unconformably underlying sandstones of Cayuga age contain fairly large deposits of ore. The largest deposits occur on the crests of anticlines where the bending of the resistant beds opened tension fractures and afforded channels for the easy circulation of ground waters. (See fig. 24 and Pl. XXVI.) Some of these deposits are unique in that they occur on the tops of the highest mountains in the region, and are believed to have been segregated in their present position largely when the tops of these mountains, now 3,000 feet or more above sea, were part of an old erosion surface or peneplain near sea level, probably in Jurassic or Cretaceous time. The deposits of the Suiter and Stange mines, two of the principal mines in the southwestern part of the State, are of this type. Other deposits that have been mined and prospected in this region are on benches

at lower levels on the flanks of the main ridges. Much of the ore that has been shipped unwashed from this region was highly siliceous, but by crushing and jigging or otherwise concentrating the ore, its grade can be greatly improved. All of it has been used for metallurgical purposes, but much of the ore recently mined in the deeper part of the cuts of the Stange mine is pyrolusite which is possibly suitable for chemical purposes.

In northwestern Virginia, especially in Shenandoah and Frederick counties, similar manganese deposits on the tops of low ridges and on terraces occur in the sandstone of Oriskany age and in chert and clay residual from the immediately underlying limestone of Helderberg age. Here the Oriskany generally rests upon limestone of Helderberg age, but the two formations are probably separated by an unconformity. The structure at most of the deposits on the ridges is monoclinal but the deposit at Powells Fort Mine in Massanutten Mountain is in a synclinal valley. The ore from the deposits in this part of Virginia is mostly pyrolusite suitable for chemical purposes. The principal mines in Frederick and Shenandoah counties are the Mineral Ridge, Powells Fort, Bonnet Hill, Godlove, and Capola Mountain mines.

ORIGIN OF THE MANGANESE ORES AND THEIR RELATION TO PHYSIOGRAPHIC FORMS.

The association of the manganese ores with particular formations, in many instances with certain beds in these formations, has led the writers to believe that the manganese was originally deposited in greater quantities in certain beds than in others, not that it formed bodies of ore there but that it was disseminated in small particles through the beds; and that it has since been dissolved by circulating groundwaters as the rocks weathered and has been redeposited in the same or in adjacent beds in the concentrated form in which it now is found.

The manganese ore in the Knox dolomite is believed to have been originally disseminated, probably as carbonate, in certain beds in the dolomite, chiefly near its base; to have been dissolved by circulating groundwaters as the limestone weathered and was dissolved; the rigid cherty limestone beds, which became brecciated by being folded with the inclosing dolomite or by caving of solution channels, furnished a free passageway to the circulating waters and the ore was redeposited in concentrated form in these passageways. Thus manganese oxide was deposited in the spaces between the fragments and to some extent was exchanged for the silica of the chert, replacing it by ore.

The ore in the Oriskany formation and associated rocks of Helderberg or Cayuga age is likewise regarded as having been originally disseminated in certain beds in the basal part of the Oriskany, which in places seem to represent initial sediments on an old land surface at the base of an unconformable series of sediments. In Bland County the interruption of sedimentary deposition and occurrence of land conditions at the beginning of the Oriskany are indicated by the presence in the basal coarse sandstone of glauconite grains, phosphate nodules, and rounded glassy quartz grains, excellently shown in the section in the vicinity of Rocky Gap (see page 36). Manganese and iron, which were originally present in these beds probably in the form of carbonates or some other soluble minerals, are now represented by wad in some layers and by brilliant coloring by iron oxides in others. Glauconite, phosphate, iron, and manganese are known to be residual products of the decay of rocks under certain weathering conditions on land surfaces, and scattered rounded glassy quartz grains are also of land origin, probably rounded by being wind blown. The concentration of the manganese minerals into workable deposits was accomplished during the more recent weathering of the rocks. The manganese was dissolved by descending circulating waters and was redeposited as oxide in channels in subjacent beds, generally in brecciated sandstones, the fragments of which were cemented and partly replaced by manganese oxide. The manganese was in most cases carried downward to the bottom of the zone of surface weathering. Where the immediately underlying beds are sandstones of Cayuga age, as in Bland and Giles counties, the ore occurs largely in these sandstones. Where the underlying rocks are cherty limestone of Helderberg age, as in parts of Shenandoah and Frederick counties, the ore replaced the chert and impure shaly limestones as well as the basal part of the Oriskany. In Massanutten Mountain it replaced sandstone masses in a brecciated zone, below a hard quartzose Oriskany conglomerate, the breccia probably resulting from the solution of underlying limestones—possibly of Helderberg age—and the caving in of the sandstone roof.

Since the Oriskany iron ores of Virginia have been regarded by T. L. Watson¹ and R. J. Holden² as having been derived from iron-bearing minerals in the Devonian shales that overlie the Oriskany, they having been dissolved by carbonated waters during weathering processes and carried to lower levels and there redeposited, it was suggested by Dr. Watson that

¹ Watson, T. L., *Mineral Resources of Virginia*: Va. Jamestown Exposition Com., pp. 408-410, 1907.

² Holden, R. J., *U. S. Geol. Survey Bull.* 427, pp. 67-68, 1910.

the manganese deposits of this region might have had a similar origin. Therefore a sample of unaltered shales that overlie the manganese-bearing beds in Bland County was collected by Dr. Watson and analyzed to determine the presence or absence of manganese. The resulting analysis showed no manganese present, but did show 4.54 per cent of iron oxides.

The accumulation of the manganese into workable deposits is believed to have occurred at times when parts of the land surface were reduced to peneplains, when the streams were nearly at base level and were sluggish and the runoff was slight, so that débris from the weathering and disintegration of the rocks at the surface accumulated to great thickness. Under these conditions, surface water percolated slowly through the decomposing material, dissolving out the soluble minerals and redepositing them in favorable localities. The iron and manganese were, as previously stated, taken into solution and carried downward to the bottom of the weathered zone, and there redeposited in interstices in the rock and in part as a replacement of silica and other minerals by chemical exchange. Therefore, many of the deposits of manganese and iron are found on the terraced floors of the various parts of the Valley of Virginia and of intermontane valleys among the Valley Ridges, having been accumulated at the time that those floors were peneplains. Most of the deposits in the Shady dolomite on the valley floor on the southeast side of the Valley of Virginia are of this type. The deposits at Round Bottom mine in Wolf Creek Valley, of the Hoffman mine and other prospects near Simmonsville in Sinking Creek Valley, and those on Manganese Ridge, Bonnet Hill, Godlove Hill, and other remnants of the valley floor in Shenandoah County are examples of this type in intermontane valleys. The Cliff and Chevy mines are on terraced spurs which are high above the adjacent valley, but these terraces represent the peneplained floor of the valley when it drained westward but which has since been deeply dissected by drainage which has been diverted eastward into the more direct course to the sea of the James.

Some deposits are found on terraces or benches high up on the flanks of mountains. Those on the south sides of East River Mountain and Buckhorn Mountain in Bland and Giles counties are of this type and these benches are probably remnants of the upland peneplain. Other deposits occur on or near the tops of the highest mountains, such as on Flat Top Mountain, Round Mountain, Big Ridge, and Johns Creek Mountain, and were largely accumulated when these surfaces were parts of a peneplain, possibly the summit peneplain. The latter deposits, therefore, are believed to be in part very old, probably Cretaceous, whereas those on the valley

floors are probably largely early Tertiary in age. Decomposition of the rocks and therefore deposition of ore has probably gone on more or less continuously to the present day on many of these peneplain surfaces where conditions have remained favorable for such action.

The peneplains with which the manganese ores are associated are fully described on pages 16-24.

ECONOMIC POSSIBILITIES.

The manganese deposits in western Virginia were, as previously stated, examined by the writers in 1918, during the period of great mining activity, and as a result of their examination at that time they prepared the following summary statement which has been published by E. C. Harder and D. F. Hewett:¹

Reserves of manganese and manganiferous ores on the west side of the Appalachian Valley in Virginia, December, 1918.

Number of deposits examined, 84.

Work concluded, September, 1918.

Number of deposits having less than 50 tons examined, 45.

Deposits that assay more than 35 per cent manganese.

Number of deposits, 25.

Reserves, 42,000 tons.

Additional reserve in prospect, 50,000 tons.

Deposits that assay from 5 to 35 per cent manganese (largely more than 30 per cent iron and less than 20 per cent silica).

Number of deposits, 14.

Reserves (no estimate).

Additional reserve in prospect (no estimate).

The above estimate of reserves are conservative for times of war needs, such as existed at the time the estimates were made. It is impossible to make an estimate of the available ore that can be mined and marketed at a profit under normal or nearly normal conditions, when such ore commands much lower prices than they did during the World War, because there are a number of factors that affect the domestic production of manganese ores in normal times. The comparatively high cost of production, the high percentage of silica in some of the ores, and the long distance of many of the deposits from railroads are some of the factors that will affect the manganese-mining industry in western Virginia. Nevertheless, this part of the State can doubtless produce some ore, especially chemical ore, at a

¹ Harder, E. C., and Hewett, D. F., Recent studies of domestic manganese deposits: Amer. Inst. Min. and Met. Eng., Trans., vol. 53, pp. 3-50, 1920. (Separate first published summer of 1919.)

profit under normal conditions in the future just as it has at times in the past. Besides the mines now in operation other deposits in the vicinity of Zepp and those in the Massanutten Mountains are most likely to be worked again, chiefly for chemical ore, and the Stange mine and other deposits on Flat Top Mountain and possibly the Suiter mine and other deposits in Bland County may possibly be worked again, chiefly for metallurgical ore. The quantity thus mined, however, will probably be considerably less than the above estimates of total available ore unless other and larger deposits are discovered.

At the present time (April, 1921) only two or three mines in western Virginia are being worked and the quantity of ore being produced, most of which is for chemical purposes, is small. Whenever conditions again cause an abnormal demand for domestic manganese ores, mining in western Virginia will doubtless be stimulated and the production will be increased.

MANGANESE MINES AND PROSPECTS

The manganese mines and prospects in western Virginia will be described in detail by counties, beginning at the north. Most of these were visited by the writers, but a few were visited by F. C. Schrader, and his descriptions will be incorporated in this report. Some showings of manganese that were reported undeveloped or whose exact location could not be learned were not visited. Some properties that were visited proved not to be manganese bearing, but are nevertheless described herein. Mines on the eastern side of the Valley of Virginia have been previously described in a bulletin (No. XVII) of the Virginia Geological Survey and are, therefore, not described in this report.

FREDERICK COUNTY.

MINERAL RIDGE MINE.

Location and geography.—The Mineral Ridge mine, also known as the Paddys Run mine, Paddy Mills mine, Paddy Hill mine, and the Nelson mine, is on Manganese Ridge in Cedar Creek Valley, $2\frac{1}{2}$ miles north of Zepp, 11 miles north of Woodstock, and $10\frac{1}{2}$ miles west-northwest of Strasburg. The ridge is known by the name of Manganese Ridge by the people who live in the region but it is called Mineral Ridge by some of the past operators of the mine. Cedar Creek Valley trends northeastward and lies between Sluice and Great North mountains on the northwest and Little North Mountain on the southeast.

Manganese Ridge is on the northwest side of the valley and extends northeastward from Hollow House Run to Paddy Run, a distance of 4,800 feet. It is really a part of a much longer ridge which has been cut in two by several water gaps through two of which Hollow House and Paddy runs flow. The northeastward continuation of the ridge beyond Paddy Run is known as Stave Mill Ridge. Manganese Ridge attains an elevation of 1,560 feet above sea level and rises about 300 feet above the runs at either end. (See Plate XVII.) The crest is narrow and straight and the slopes are steep. At its east base there is a gently rolling area with an elevation of about 1,300 feet above sea level. As this and numerous similar areas on the west side of Cedar Creek Valley attain the same elevation they are regarded as remnants of a former peneplain. Several ridges in the valley rise

above this level, but of these Manganese Ridge and Bonnet Hill, which is 1,610 feet above sea level, are the highest. They are believed to be remnants of a somewhat higher peneplain.

Hollow House Run is perennial below Hollow House Spring but is of small size. Paddy Run is a perennial stream of fair size and supplied water for the manganese ore-washing plants which have been operated at times for many years. A small spring occurs on the right bank of the run at the County Road Bridge and a larger spring from which drinking water is obtained for the miners is a short distance west of the bridge. The permanent ground water level in Manganese Ridge is lower than the lowest opening—a tunnel whose floor has an elevation at the portal of 1,438 feet above sea level. How much below this elevation it occurs is not known but it is perhaps 80 feet or more.

History and production.—Charles F. Nelson, of Strasburg, one of the owners of the mine, has kindly furnished most of the information that has been used in the preparation of this chapter.

Manganese ore is reported to have been mined on Manganese Ridge and marketed as early as 1834. A mill for the washing and grinding of the ore was operated many years before the Civil War on Paddy Run just west of the County Road Bridge, but a few years before the war the mill was moved to a point on the run east of the bridge where it was operated both before the Civil War and for many years after the war. Samuel Pancoast is said to have operated the mine about 1836 and Lorangia Seibert for 10 or more years thereafter. William Remsen, of New York City, was apparently also one of the early operators of the mine and mill. The records in the Clerk's Office of Frederick County, Virginia, show that the mineral right of the property on which the mine is located was conveyed to him on June 22, 1846. Another early operator was Jos. W. Patterson, who purchased the property from Mr. Remsen on Nov. 11, 1865. He continued work until 1877 or 1878. The ore that was marketed by him was mainly hauled to Winchester and Woodstock, Va., for shipment. On March 8, 1878, the property was sold by Mr. Patterson to Myron C. Davis, who deeded it on March 9, 1878, to Josiah L. Woodward. Mr. Woodward is said to have worked the mine for several years, ending in 1885. J. D. Weeks¹ makes the following statements which are contained in a report that was published in 1886: "There have been removed from this mine some 2,000 tons of ore, mostly before the war and by very imperfect

¹ Weeks, J. D., U. S. Geological Survey Mineral Resources U. S. 1885, p. 324, 1886.

methods of mining. No shaft has gone below 50 feet." The heirs of Mr. Woodward sold the mine in 1893 to Charles F. Nelson and his associates, who are the present owners. Some prospecting was done between 1893 and 1915. Mining on a comparatively small scale has been done in recent years by different operators, beginning in 1915 and continuing until the time of last visit (July, 1920). About 1,500 tons of manganese ore was produced and shipped during this period and most of it was used by manufacturers of ferromanganese. The rest of it was used for chemical purposes. The mine was operated in 1915 and 1916 by Orndorff & Vance, but was operated a part of 1916 by C. M. Clay and later by J. T. Orndorff. Mr. Orndorff was succeeded in August, 1917, by the Shaffer Engineering Co., Nazareth, Pa., operating under the name North Georgia Land & Mineral Co., of Nazareth, Pa., which erected a manganese-ore washing plant, and this company was in turn succeeded on April 1, 1918, by the Mineral Ridge Manganese Corporation. This corporation operated the mine and the washing plant until October 1, 1919, when it was followed by Charles F. Nelson, and on April 1, 1920, he was followed by N. H. Mannakee, who has worked the mine under the trade name Hy-Grade Manganese Co. The manager for this company is J. Carson Adkerson, of Woodstock. This company was at the time of last visit (July, 1920) doing development work with the intention of later operating the mine and erecting a mill on Paddy Run for the concentration of the ore. Some ore was, however, being obtained during the development work and this was hand-picked and then marketed. The Hy-Grade Manganese Co. had marketed 500 tons of ore before April, 1921, which was used in steel manufacture, in the manufacture of bricks, and in the manufacture of dry cell batteries. The washing plant that was used by Mr. Nelson and earlier operators has not been used by this company but has been dismantled. The total production of the mine before April, 1921, was about 4,000 tons of ore.

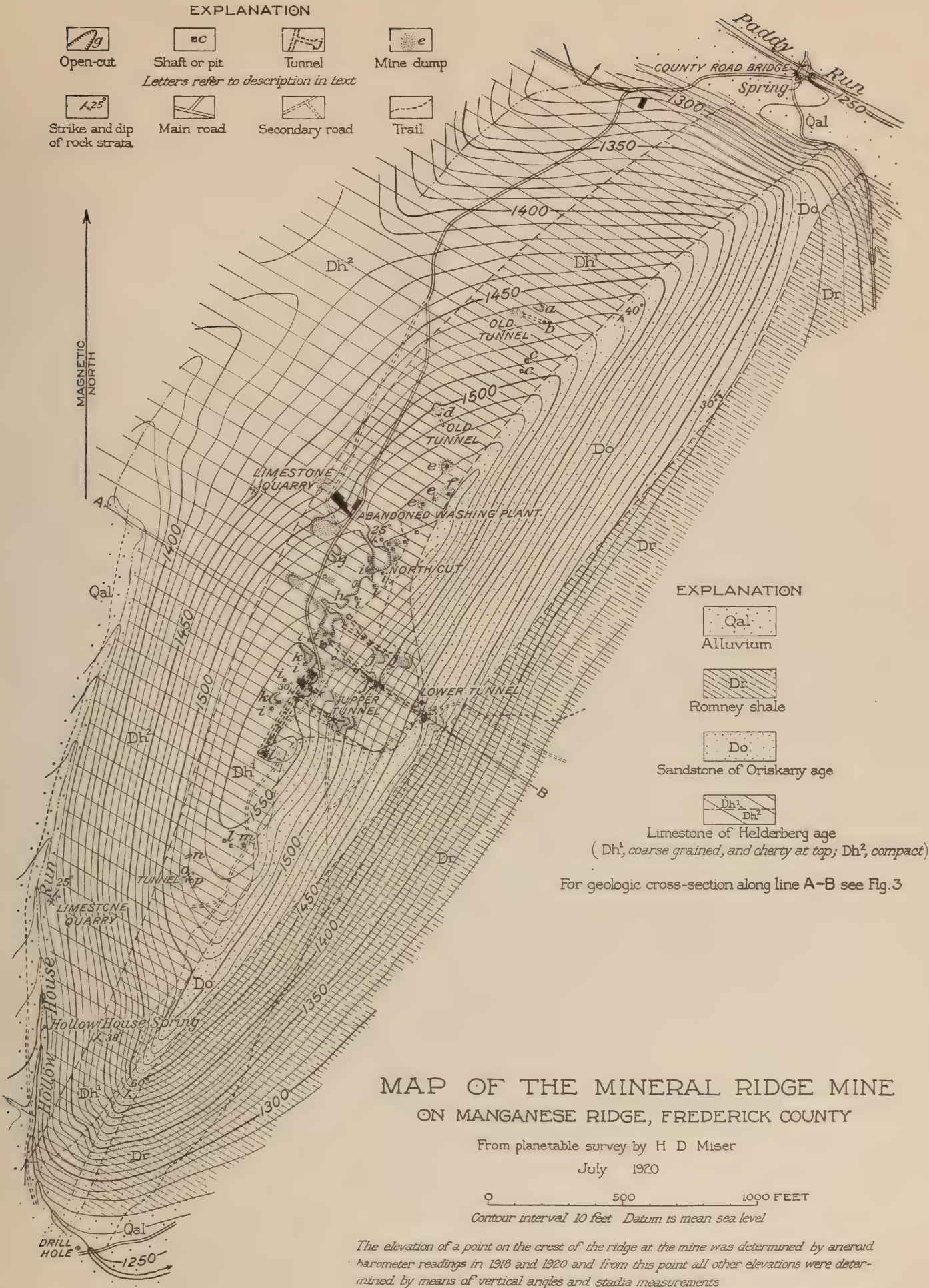
Workings.—The workings occur at places along the crest of the ridge for a distance of 2,500 feet, but most of them are at and near the middle part of the ridge. They consist of open cuts, pits, shafts, and tunnels. The shafts, which are as much as 50 feet deep, have been used both in prospecting for manganese ore and mining it. They have, however, not been used in recent years for mining ore. Open cuts and tunnels were used extensively by the early operators and have been used exclusively by the recent operators. The old cuts and tunnels caved in many years ago so

that very little is known about them. The largest cuts that have been made recently are designated on the map (Pl. XVII) as North Cut and South Cut. The face of each of these is about 15 feet high at the highest places. Only two tunnels, which are indicated on the map (Pl. XVII) as the Upper and Lower tunnels, were accessible at the time of last visit (July, 1920). The upper one occurs at an elevation of 1,519 feet above sea level, or 40 feet below the highest point on the crest of the ridge and extends west-northwestward into the ridge, a distance of 150 feet, and from its northwest end two parallel drifts, 15 feet apart, had been run 100 feet to the northeast and two such drifts had also been run 250 feet to the southwest. Cross cuts connect the parallel drifts at several places and stopes have been made above the drifts. The lower tunnel occurs at an elevation of 1,438 feet above sea level or 120 feet below the highest point on the crest of the ridge and extends 268 feet in a west-northwestward direction. At a distance of 163 feet from the portal a drift had been run 84 feet to the northeast and another drift had been run 114 feet to the southwest. Small stopes had been made above both drifts.

Geology.—The sequence of rocks in the vicinity of the mine is as follows:

Feet.	
60±	Coarse, granular fossiliferous sandstone of Oriskany age.
50±	Yellow sandy clay containing a few chert nodules; derived from impure limestone probably of Helderberg age.
50±	Ore zone, 15 to 27 feet thick, in massive and thin-bedded chert, about 50 feet thick, with thin partings of red and yellow clay; few fossils of Becraft (upper Helderberg) age.
100	Thick and thin bedded, dark-gray, coarse, fossiliferous limestone and dark siliceous knotty limestone; fossils of New Scotland (Helderberg) age.

The ore deposit occurs in a bed of chert, about 50 feet thick, which crops out along or near the crest of Manganese Ridge and which consists of chert in thick and thin layers and a small amount of red and yellow clay that is interbedded with the chert. The chert is cut by many fractures and at places has been broken into numerous fragments. Most of it is hard and compact but some is soft and porous and it, like the overlying and underlying rocks which are described below, dips at high angles averaging 35° to 40° to the southeast (see fig. 3), and strikes northeast parallel with the trend of the ridge. It has probably been derived from the weathering of a cherty limestone. Fossils which were obtained from the cherty clay on the dump of one of the shafts are said by E. O. Ulrich to be of Becraft age, or uppermost Helderberg.



The fact that the lower tunnel passed through chert at an elevation of 1,438 feet, or 120 feet below the highest point on the ridge, indicates that the limestone has been deeply weathered and the chert and clay may extend downward a considerable distance—perhaps 80 or 100 feet below the level of the lower tunnel—before it changes to unaltered limestone from which they have apparently been derived. Although the chert bed dips at high angles to the southeast, its individual layers have been bent into small folds or wrinkles, so that the dips of the layers in a single exposure may range from nearly horizontal to almost 90° toward the southeast. This bending of the layers is attributed to their unequal settling while the limestone was being removed through solution. In the upper tunnel the dips of the chert and clay layers range from nearly horizontal to 70° toward the southeast but apparently average between 35° to 40° in this direction. In the lower tunnel the beds are horizontal in places and vertical at other places, but most of the dips are apparently between 35° and 40° toward the southeast. The chert, as it is revealed in the north and south cuts, dips at different angles to the southeast, but in parts of the cuts it has been fractured so much that all traces of the bedding have been destroyed.

The ore-bearing chert bed is overlain by a yellow sandy clay about 50 feet thick in which there are a few chert nodules. This clay has been penetrated by a few prospect shafts and pits on the crest of the ridge and by the lower and upper tunnels. It has probably been derived from the weathering of impure limestone beds at the top of the Helderberg limestone, but there are no exposures of the limestone from which it is believed to have been derived.

Underneath the ore-bearing chert there is a bed of limestone 100 feet thick which is composed of thick and thin beds of dark-gray coarse-grained fossiliferous limestone and of dark-colored knotty siliceous limestone. It contains a small amount of chert in veins which cut across the bedding. There are a number of exposures of the limestone; the largest of them are on the west slope of Manganese Ridge above Hollow House Spring. Another exposure is in Paddy Run just below the County Road bridge, and another is in the North cut where the dip is 25° SE. This limestone was encountered at the northwest end of the lower tunnel. A few fossils that were obtained from the limestone are said by E. O. Ulrich to indicate Helderberg age, probably equivalent to the New Scotland limestone of New York.

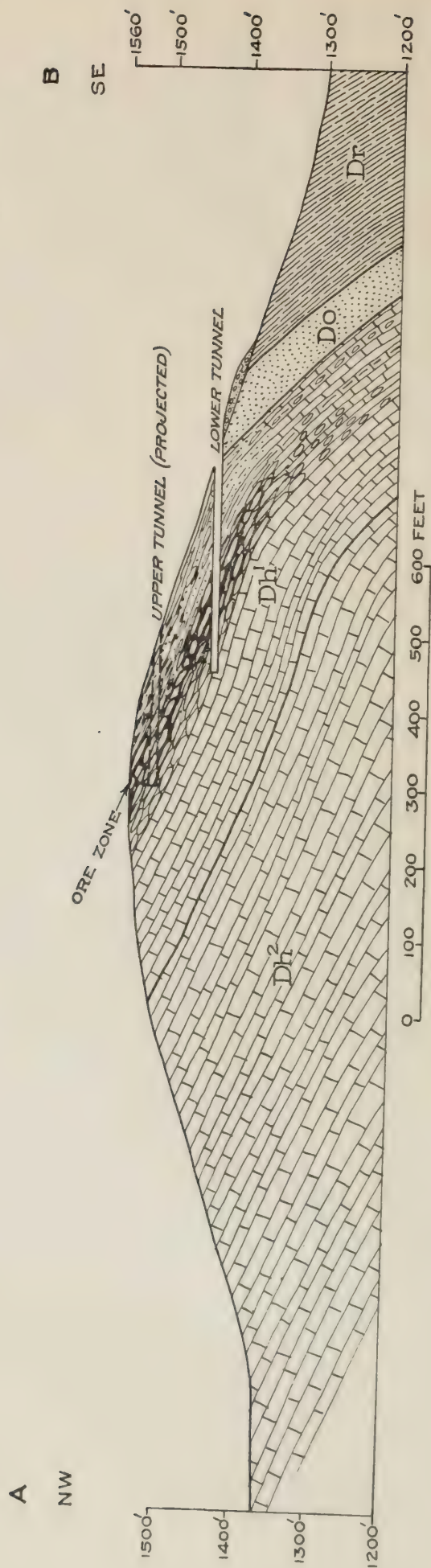


Fig. 3.—Geologic cross section through Mineral Ridge, Frederick County (along line A-B on Place XVII), illustrating the occurrence of the manganese-ore deposit. Dr, Romney shale; Do, Oriskany sandstone; Dh, Helderberg limestone (Dh¹, coarse-grained and cherty at top; Dh², compact). Black represents ore.

A still lower bed of limestone which is composed of massive, compact, dark-colored limestone, shaly limestone, and blue laminated limestone is exposed at numerous places on the hill slope east and north of Hollow House Spring. Limestone has been quarried from the massive beds at two places and has been burned into lime for local use. Fossils from it are said by E. O. Ulrich to determine its age as Helderberg, probably the equivalent of the Keyser limestone member of West Virginia and Maryland, which is older than the New Scotland.

Oriskany sandstone forms the crest of Manganese Ridge northeast of the mine and much of the crest southwest of the mine. It is separated from the ore-bearing chert by the 50-foot bed of sandy clay described above. At the southwest end of the ridge it is about 50 feet thick and dips 60° SE.; at the mine it is about 60 feet thick and apparently has a dip of 45° SE.; and at the northeast end of the ridge is about 100 feet thick and dips 30° to 40° SE. At the mine the outcrop of the sandstone swings eastward so that it is there between 100 and 150 feet below the crest of the ridge. The tunnels that were run westward into the ridge start above the outcrop of the sandstone and therefore do not pass through it, but if tunnels are made elsewhere on the east slope in search of ore in the chert of Becraft age they will have to pass through this sandstone. The outcrops of the sandstone are marked by heavy ledges and huge boulders. The sandstone is hard, coarse-grained and gray and contains many quartz pebbles as much as a quarter of an inch in diameter.

A black shale (Romney shale) of Devonian age overlies the Oriskany. There are, however, very few exposures of it in the area that is represented on the accompanying map (Pl. XVII).

The stream wash which underlies the narrow flats along Hollow House and Paddy runs consists of sand, sandy loam, and masses of sandstone ranging in size from a fraction of an inch to 8 feet in their longest dimension. Its thickness at the County Road Bridge across Paddy Run where there are outcrops of the Helderberg limestone is 10 feet, but the absence of limestone outcrops at other places along the stream indicate that the thickness at such places exceeds 10 feet. The thickness along Hollow House Run is not known.

Manganese-ore deposit.—The deposit of manganese ore occurs, as previously stated, chiefly in the bed of chert, about 50 feet thick, that has been derived by weathering from the upper part of the Helderberg limestone. Some manganese oxide fills small crevices in the overlying Oriskany

sandstone. The ore is irregularly distributed through a zone from about 15 to 27 feet thick in the middle or upper part of the chert. The dip and strike of the ore body are therefore the same as those of the chert beds. The strike is to the northeast, parallel with the trend of the ridge, and the dip at the mine apparently averages between 20° to 25° to the southeast, but it increases to 40° or more in this direction both northeast and southwest of the mine. The workings show that ore occurs along the ridge, a total distance of 2,500 feet. The greatest depth from which ore had been mined before December, 1919, was 50 feet, but about the first of December of that year the lower tunnel penetrated the ore-bearing zone at an elevation of 1,438 feet above sea level or 120 feet below the highest point on the crest of the ridge. How much deeper the ore extends is not known but it is perhaps 80 feet or more.

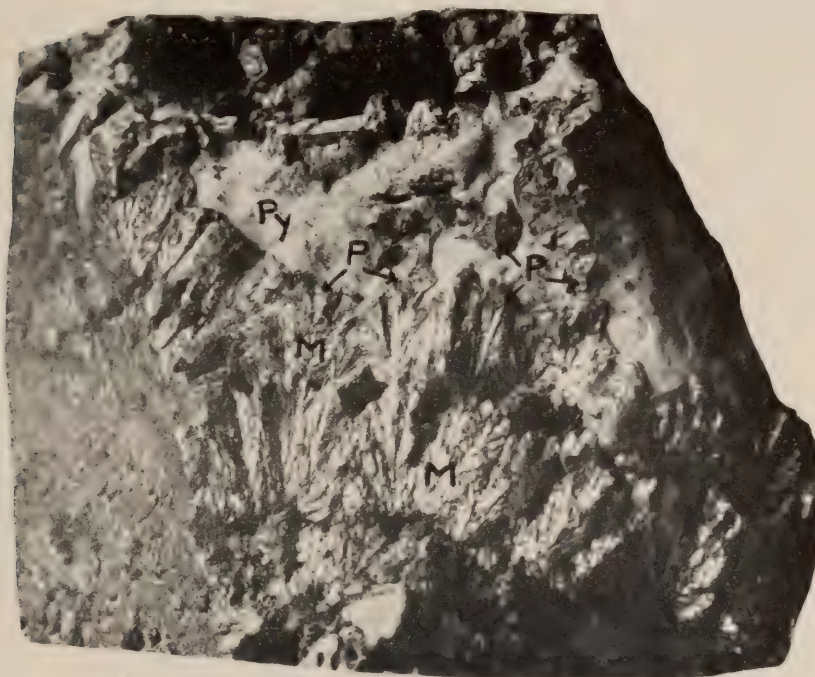
The ratio of ore to ore-bearing chert and clay in the ore zone differs from place to place, but thus far very little is known of the actual ratio. The washing plant that was operated in recent years is said to have obtained one ton of concentrates from every 8 to 10 tons of ore-bearing chert and clay but much ore in fine particles was not saved in the plant.

Most of the ore occurs as seams parallel with the bedding of the chert and clay; the rest occurs along fractures that cut the chert layers and cements chert fragments together, thus being a breccia-filling material. The seams are generally a few inches thick but at places they are as much as 3 feet thick.

The manganese ore includes the minerals pyrolusite, wad, manganite, and psilomelane, of which pyrolusite is the most abundant. They are all more or less intimately mixed and are present in the upper tunnel, in the north and south cuts, and probably in most of the other shallower workings, but the proportion of pyrolusite increases with depth so that the other minerals are present only in very small quantities in the lower tunnel. Brown iron oxide occurs with the manganese oxides in the tunnel, marked O on Pl. XVII, on the southwest part of the ridge and in the hanging wall side of the ore-bearing zone in the upper tunnel. Brown iron oxide, apparently free from manganese oxides, was found in the shaft marked M on Pl. XVII, on the southwest part of the ridge. Besides iron oxide the only mineral that is associated with the manganese minerals is quartz. This is present in clear crystals which are usually a fraction of an inch long but many are half an inch across. Some of the crystals are doubly terminated.



(A) Fossils in psilomelane, Bonnet Hill mine, Shenandoah County.



(B) Manganite having a radiate fibrous structure (M), embedded in psilomelane (P), and pyrolusite (Py). Mineral Ridge mine.

The pyrolusite is bluish black in color, is fine grained, and is soft enough to be crushed between the fingers, which it blackens. Very little of it holds together sufficiently for specimens the size of a person's fist to be obtained. Most of it when handled falls to an impalpable powder which passes through a screen of 200 mesh to the inch. An analysis of a picked sample of pyrolusite is given as No. 28 in the accompanying table. The psilomelane is black and steel blue in color, and much of it has smooth botryoidal surfaces. Some of the masses with such surfaces are pendant-like in form and are $1\frac{1}{2}$ inches long. (See Pl. IX.) The wad is brownish black in color and is soft though firm enough that it will not disintegrate into powder or small pieces. Analyses are said to show that it contains between 40 and 45 per cent of manganese. Some of it occurs as particles a fraction of an inch in diameter disseminated through the pyrolusite giving specimens of such pyrolusite a spotted appearance. The manganite occurs as radiating crystals enclosed in fine-grained pyrolusite, but at places is enclosed in psilomelane. (See Pl. XVIII.) It also occurs as minute tabular crystals that line cavities in pyrolusite.

The relations of the manganese minerals to the clay and chert indicate that they have filled fissures in the chert and that they have replaced parts of the chert and clay.

Analyses of samples of ore and of carload lots of ore that were shipped for metallurgical purposes are given in the accompanying table. The so-called first and second grades of ore for such purposes consisted largely of pyrolusite and are therefore sometimes called soft ore, whereas the washed ore that was marketed consisted largely of psilomelane and manganite. Several of the accompanying analyses indicate that the ore at this mine contains from 6 to 10 per cent of barium oxide.

Analyses of manganese ore from the Mineral Ridge Mine.

	Manga- nese (Mn)	Iron (Fe)	Phos- phorus (P)	Baryta (BaO)	Silica (SiO ₂)	Alumina (Al ₂ O ₃)	Moisture	Manga- nese dioxide (MnO ₂)
1.	50.	4.	.09-.10	.....	.....	.....	.....	.....
2.	48.64	.....	.....	.....	.....	.....	10.25	.....
3.	44.76	3.90	.296	.....	7.10	9.20	1.25	.....
4.	52.67	.85	.227	.....	1.08	.....	1.57	.....
5.	48.34	3.25	.226	.....	7.05	.....	1.58	.....
6.	49.18	1.30	.284	.....	2.05	.....	5.46	.....
7.	50.28	3.25	.257	.....	5.43	.....	1.60	.....
8.	48.03	4.50	.261	.....	5.55	.....	7.65	.....
9.	45.61	5.57	.23	.....	5.78	.....	5.71	.....
10.	45.59	6.18	.42	6.87	.85	1.62	.....	.....
11.	43.47	4.10	.27	.....	9.51	.....	6.20	.....
12.	39.53	7.10	.....	.....	9.60	.....	.....	.....
13.	42.16	4.08	.....	.....	3.14 ^a	.....	.....	.....
14.	42.77	5.14	.23	.....	8.06	.....	9.06	.....
15.	44.50	.....	.....	.....	8.02	.....	12.32	.....
16.	41.08	.....	.....	.....	10.63	.....	3.00	.....
17.	42.02	4.98	.29	.....	10.54	.....	5.70	.....
18.	47.90	.20	.270	.....	1.46	.....	.....	.....
19.	53.25	3.02	.263	.....	1.80	.....	.....	.....
20.	54.40	1.67	.144	6.95	1.60	.....	.....	82.00
21.	52.99	1.57	.....	8.20	2.40	.....	.....	78.50
22.	53.34	1.57	.....	7.91	2.45	.....	.....	80.50
23.	52.52	1.17	.....	9.78	3.20	.....	.....	79.60
24.	52.75	.98	.....	9.45	2.95	.....	.....	80.50
25.	50.17	1.00	.....	9.61	6.65	.....	.....	78.02
26.	54.29	1.68	.21	7.14	1.93	.....	.....	77.74
27.	43.37	7.86	.....	9.12	6.40	.....	.....	65.10
28.	60.39	.19	.....	.....	.25	.....	.....	95.50
29.	48.14	4.03	.23	.....	6.13	.....	.....	.....
30.	51.97	1.76	.22	.....	3.22	.....	.....	.....
31.	48.36	2.65	.24	.....	3.41	.....	.....	.....
32.	48.93	1.50	.....	.....	4.40	.....	.....	.....
33.	.....	1.03	.....	.....	3.33	.....	.....	84.00

^a Includes alumina.

1. Average analysis of hard ore associated with the soft ore from J. D. Weeks, U. S. Geol. Survey Mineral Resources U. S. for 1885, pp. 324-327, 1886.
2. Analysis of carload of ore shipped in 1915 by Chas. F. Nelson for Orndorff & Vance to American Manganese Co.
3. Analysis of carload of ore shipped in 1916 by Chas. F. Nelson for J. T. Orndorff.
- 4-5. Analyses of carload lots of hard blue ore shipped in 1917 by J. T. Orndorff to E. E. Marshall.
6. Analysis of carload of black ore shipped in 1917 by J. T. Orndorff to E. E. Marshall.
- 7-8. Analyses of carload lots of fine soft blue ore shipped in 1917 by J. T. Orndorff to E. E. Marshall.

- 9-10. Analyses of carload lots of soft ore shipped in 1918 by Mineral Ridge Manganese Corporation to the Tennessee Coal, Iron & Railroad Co.
- 11-13. Analyses of carload lots of washed ore shipped in 1918 by Mineral Ridge Manganese Corporation to the Tennessee Coal, Iron & Railroad Co.
14. Analysis of carload of soft ore shipped in 1919 by Mineral Ridge Manganese Corporation to the Tennessee Coal, Iron & Railroad Co.
15. Analysis of carload of mixed ore (soft and washed) shipped in 1919 by Mineral Ridge Manganese Corporation to the Tennessee Coal, Iron & Railroad Co.
- 16-17. Analyses of carloads of washed ore shipped in 1919 by the Mineral Ridge Manganese Corporation to the Tennessee Coal, Iron & Railroad Co.
- 18-19. Analyses of samples of ore. Gulick-Henderson Co., analysts.
- 20-25. Analyses of average samples of the "first grade" ore removed in January, February, and March, 1920, from the lowest tunnel. Alexander Fleming, analyst.
26. Analysis of average sample of the "first grade" ore removed in January, February, and March, 1920, from the lowest tunnel. Froehling & Robertson, analysts.
27. Analysis of average sample of second grade ore. Alexander Fleming, analyst.
28. Analysis of picked sample of first grade ore (pyrolusite). Alexander Fleming, analyst.
- 29-31. Analyses of carloads of ore shipped by the Hy-Grade Manganese Co. to the Tennessee Coal, Iron & Railroad Co.
32. Analysis of carload of ore shipped by the Hy-Grade Manganese Co. to the Tennessee Manganese Co., Knoxville, Tenn.
33. Analysis of shipment of chemical ore shipped by the Hy-Grade Manganese Co. Analysis by Leebrick Chemical Laboratory, Elkton, Va.

The ore-bearing zone in the upper tunnel is 27 feet thick, but most of the ore occurs next to the footwall and also next to the hanging wall. For this reason parallel drifts 15 feet apart were made from the tunnel. The ore next to the hanging wall is mixed with much iron oxide and therefore contains a high percentage of iron, whereas the ore next to the footwall contains a very low percentage of iron. The ore-bearing zone in the lower tunnel is between 15 and 18 feet thick. Very little iron oxide is associated with the ore and pyrolusite is by far the most abundant manganese mineral. The ore from this and also the upper tunnel has so far been freed by hand from the chert and clay and has been sorted into three grades, one of chemical ore, and two of metallurgical ore. The ore-bearing zone

in the north and south cuts appears to be between 20 and 30 feet thick. Psilomelane is one of the principal manganese minerals in them.

Many other openings which are indicated on the map (Pl. XVII) are briefly described below. The letters here used correspond to those on the map:

- a. Very old cut in chert; apparently yielded manganese ore.
- b. Very old tunnel in chert; completely caved in; apparently yielded manganese ore.
- c. Old shafts in chert from which some manganese ore was apparently produced.
- d. Very old tunnel; completely caved in; chert on dump contains signs of manganese ore; masses of knotty impure limestone that are on dump were obviously removed from tunnel.
- e. Old shafts in chert; material on dumps indicates presence of manganese ore.
- f. New shaft in yellow sand in which there is a small quantity of chert; no manganese ore was obtained.
- g. Shallow new cuts in chert from which very little or no manganese ore was obtained.
- h. Very old cuts in chert from which manganese ore was mined.
- i. Shafts in chert from which manganese ore has been mined.
- j. Very old tunnels; completely caved in; manganese ore was mined from them.
- k. Depressions formed by caving in of drifts that were run from adjacent shafts.
- l. Very old shafts in chert and clay; apparently yielded some manganese ore.
- m. New shaft in chert and yellow clay; brown iron ore was found; manganese ore was apparently not found.
- n. New cut in yellow cherty clay; a small quantity of manganese ore was found.
- o. Tunnel in cherty clay; manganiferous iron ore and manganese ore were found.
- p. Shaft in cherty clay; only a small quantity of manganese ore appears to have been found.

A prospecting drill hole for manganese ore was made several years ago in the flat of Hollow House Run at the southwest end of Manganese Ridge. The depth of the drill hole and the character of the rocks that were passed through are not known.

Mining and preparation of ore.—Prior to 1915 the mine was worked by means of shafts as much as 50 feet deep, by open cuts, and by tunnels. The ore was probably hand-picked to free it from the chert and clay, and some of it is said to have been washed and ground in a mill on Paddy Run.

In 1915 and subsequent years the mine has been worked by means of open cuts and tunnels. The tunnels entered the east slope of the ridge and ran directly into the ridge. When the ore-bearing zone was encountered drifts were run in either direction following the zone. When the desired length of drift was reached, overhand stoping of the ore-bearing material was begun at the ends of the drifts and progressed toward the tunnels. In July, 1920, most of the ore-bearing material had been removed from above the drifts that run southwest from the upper tunnel, and at that time the two drifts from the lower tunnel were being driven and some overhand stoping was being done in them. The ore from the tunnels is mostly very soft and thus far has been sorted by hand from the clay and chert during the mining. The crude ore that was treated in the washing plant by the North Georgia Land & Mineral Co., the Mineral Ridge Manganese Corporation, and Charles F. Nelson, was obtained from the dumps of the old workings and from the north and south cuts and a few smaller cuts. Mining was done by hand and the ore was hauled in wagons. The plant was equipped with a 24-foot single log washer, three jigs, a trommel screen, and an Empire concentrating table. Water was pumped through 2,240 feet of 2½-inch pipe from Paddy Run, from which the lift was about 260 feet. All of the ore that has been marketed in recent years has been hauled in trucks and wagons a distance of 15 miles to Capon Road station on the Baltimore & Ohio Railroad for shipment.

During the development work that was in progress at the time of last visit (July, 1920) the ore was being hand-picked to free it from the clay and chert and was sorted into three grades—one for chemical ore and two for metallurgical ore. Since then some ore has also been shipped for use in making bricks. Much of the ore cannot be saved by hand-picking and the ore-bearing waste is placed on separate dumps from the barren waste for future treatment. A sample from one of the ore-bearing waste dumps is said to have contained 21 per cent of manganese.

MOSES ORNDORFF PROSPECT.

The Moses Orndorff prospect is on the Moses Orndorff place on Stave Mill Ridge, 3 miles north-northeast of Zepp. (See fig. 4.) A shaft 12 feet deep has been made recently on the southwest end of the ridge at an elevation of less than 50 feet above Paddy Run. As the ridge is in line with Manganese Ridge to the southwest, it was believed to possess favorable conditions for ore. The shaft penetrated beds of pebbly sandstone and sand in the Oriskany formation, which here dips at an angle of perhaps

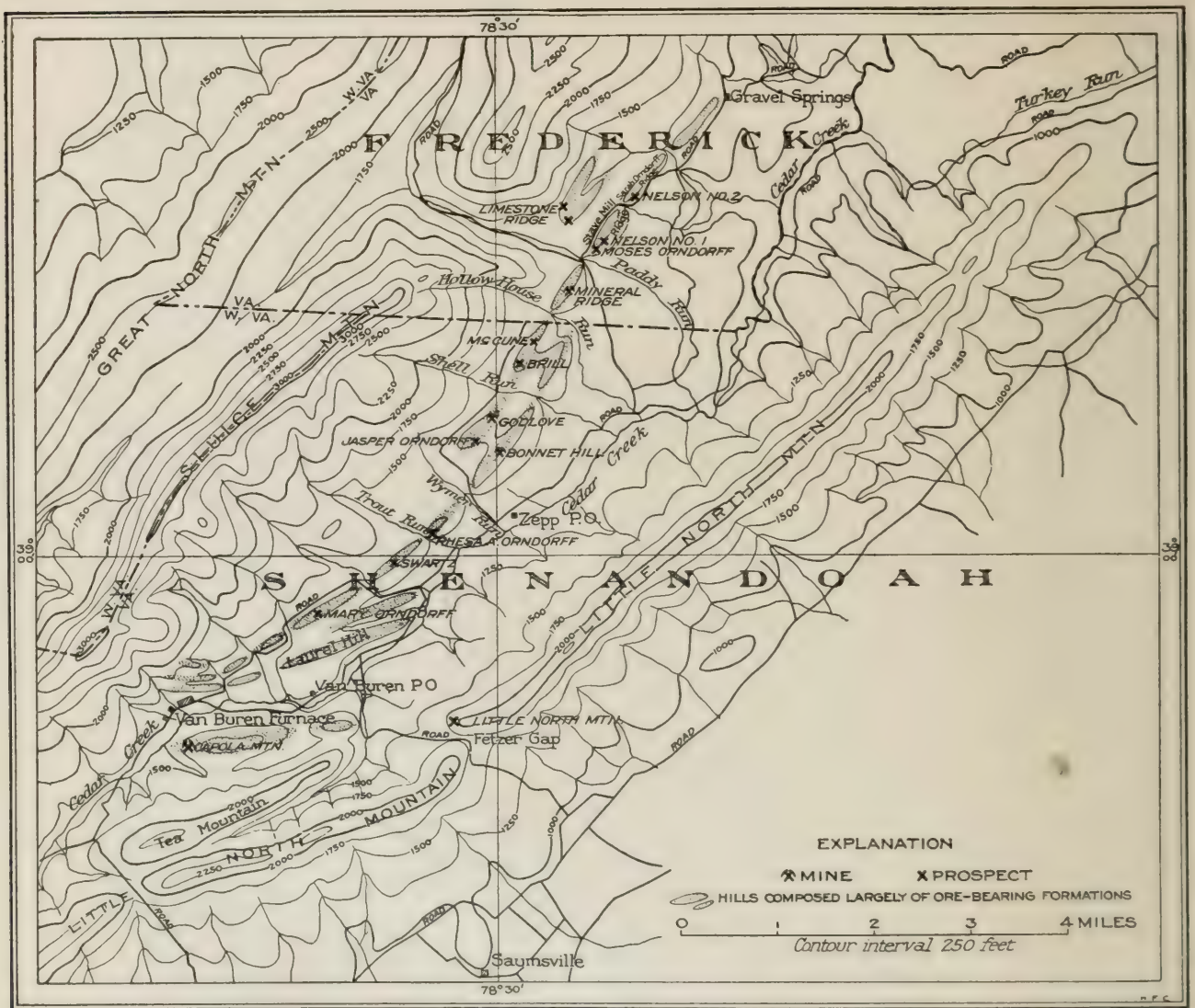


Fig. 4.—Sketch map of a part of Cedar Creek Valley, Frederick and Shenandoah counties, showing the location of the manganese mines and prospects and of hills on which ore-bearing formations occur.

35° or 40° to the southeast. Sandy manganese oxide in a vein as much as 1½ inches thick was found near the surface but the quantity of it is far too small to be of commercial importance.

NELSON NO. 1 PROSPECT.

The Nelson No. 1 prospect, which is on the property of Charles F. Nelson, is on the east slope of Stave Mill Ridge one-third mile north of Paddy Run. Mr. Nelson has recently made a tunnel extending in a northwest direction into the ridge. The tunnel at the time of visit (July 18, 1920) was 132 feet long and its entire length had been made in Oriskany sandstone. The sandstone is perhaps 100 feet thick and dips 30° to 35° SE. This means that the tunnel may have to be extended between 50 and 75 feet farther to pass through the sandstone into the underlying rocks. The formation that underlies the Oriskany is the Helderberg limestone and as on Bonnet Hill and Manganese Ridge, its upper part has deeply weathered at the surface so that the unaltered limestone is overlain by chert and clay which are residual from it. At some places the chert and clay extend at least 100 feet below the surface, and at the Bonnet Hill and Mineral Ridge mines they contain manganese ore in minable quantity at that depth. It is believed that similar conditions exist on Stave Mill Ridge; and the tunnel was started to determine whether or not the chert and clay residual from the Helderberg limestone, beneath the Oriskany, contain manganese ore. This has not yet been determined.

NELSON NO. 2 PROSPECT.

The Nelson No. 2 prospect is on the southeast slope of the Sarah Orndorff Ridge, which is northeast of, and in line with, Stave Mill Ridge. The mineral right of the property on which the prospect is located is owned by Charles F. Nelson. Mr. Nelson has recently begun the driving of a tunnel in a northwest direction through the Oriskany sandstone with the hope of finding manganese ore in the underlying beds, which are probably chert and clay residual from the Helderberg limestone. Fragments of manganese ore are said to have been found on the northwest slope of the ridge where the chert and clay reach the surface.

The tunnel at the time of visit (July 18, 1920) was 60 feet long and the entire length was in Oriskany sandstone, which is massive and hard and which dips 35° to 40° SE.

LIMESTONE RIDGE PROSPECT.

Limestone Ridge lies between Great North Mountain to the northwest and Stave Mill and Sarah Orndorff ridges to the southeast. It is a double ridge with a northeastward trend and the two prongs unite at the southwest end where the ridge is highest. The southwest end is one mile north of Paddy Run and about $1\frac{1}{2}$ miles north of the Mineral Ridge mine.

The crest of the ridge is formed in part by Oriskany sandstone and in part by beds of chert of Helderberg age. The chert is underlain by limestone also of Helderberg age, of which there are numerous and large exposures on the south end and east slope. The formations in this ridge lie in a syncline (see fig. 5), which plunges northeastward and whose southwest end is shaped like the end of a canoe.

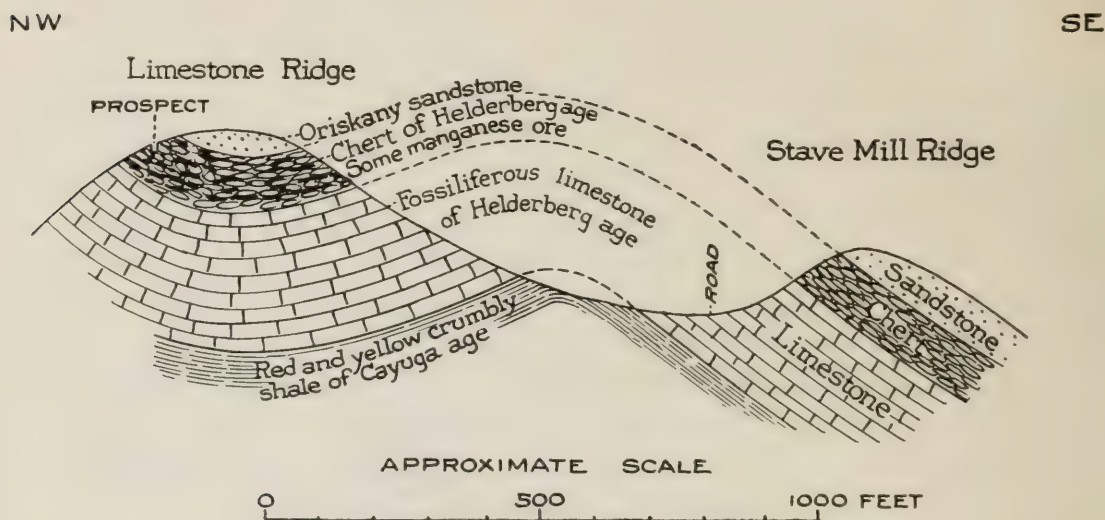


Fig. 5.—Sketch geologic cross section through Limestone Ridge at the Limestone Ridge prospect, Frederick County.

On the upper west slope of the south end, 100 feet below the top which is capped by coarse, reddish sandstone of Oriskany age, S. R. Heishman put down a large hole some years ago, which had slumped to 10 feet depth at the time of visit. It exposed brecciated chert cemented and in part replaced by manganese oxide inclosed in dark wad soil. Few fragments of hard ore were seen. On the upper south slope of the hill, chert and sandstone fragments more or less impregnated with manganese oxide strew the surface, and were derived from outcrops of the chert near the top of the hill.

Prospecting for manganese ore in recent years has been done on the south end of the ridge and at other places by Alexander Fleming and

other parties, but at the time of visit (July 18, 1920) manganese ore in commercial quantity had not been discovered. The prospecting had been done by means of pits. The pits that were examined penetrated chert, sand, and sandy clay, which are residual from the Helderberg limestone.

SHENANDOAH COUNTY.

BRILL PROSPECT.

The Brill prospect, which is on the John Martin Brill place, is on Fox Ridge about one-eighth mile north of Shell Run and the same distance north of the Godlove mine. (See fig. 4.) The mining rights are optioned by W. H. Wyand for the Maryland Mining & Fruit Co., of Hagerstown. The part of the ridge on which the prospect is located trends northeast and its crest is formed by Oriskany sandstone, which strikes N. 30 E. and dips 30° SE. into a local syncline. The Helderberg limestone, which underlies the sandstone, is the surface formation on the west slope and in part of the valley west of the ridge, whereas the Romney shale, which overlies the sandstone, is the surface formation in the valley east of the ridge.

A pit 20 feet deep was made on the crest of the ridge about 15 years ago, but had partly caved in before the time of visit. It penetrated pebbly beds of the Oriskany sandstone, which carries some manganese oxide, and produced about 2 tons of manganese ore, which was still on the dump at the time of visit. The ore consists entirely of pyrolusite and occurs as thin veins and pockets in the fractured sandstone. The amount that was obtained from the small pit indicates that a large proportion of the ore-bearing sandstone was ore. The ore, however, contains much silica as sand grains and quartz pebbles whose presence indicate that it has replaced the sandstone. A ledge of iron ore in the upper part of the sandstone crops on the crest of the ridge.

McCUNE PROSPECT.

The McCune prospect is on Fox Ridge one-fourth mile northeast of the Brill prospect and three-eighths of a mile north of Shell Run. It is on the Rose Brill place, of which the mineral right is said to be owned by Samuel McCune, of Meadow Mills, who has given an option to W. H. Wyand, of Hagerstown. The part of the ridge on which the prospect occurs trends northeast and its crest is formed by Oriskany sandstone, which strikes N. 30 E., and dips 40° SE. The Helderberg limestone

underlies the valley west of the ridge and the Romney shale underlies the valley east of the ridge just as they do farther southwest near the Brill prospect.

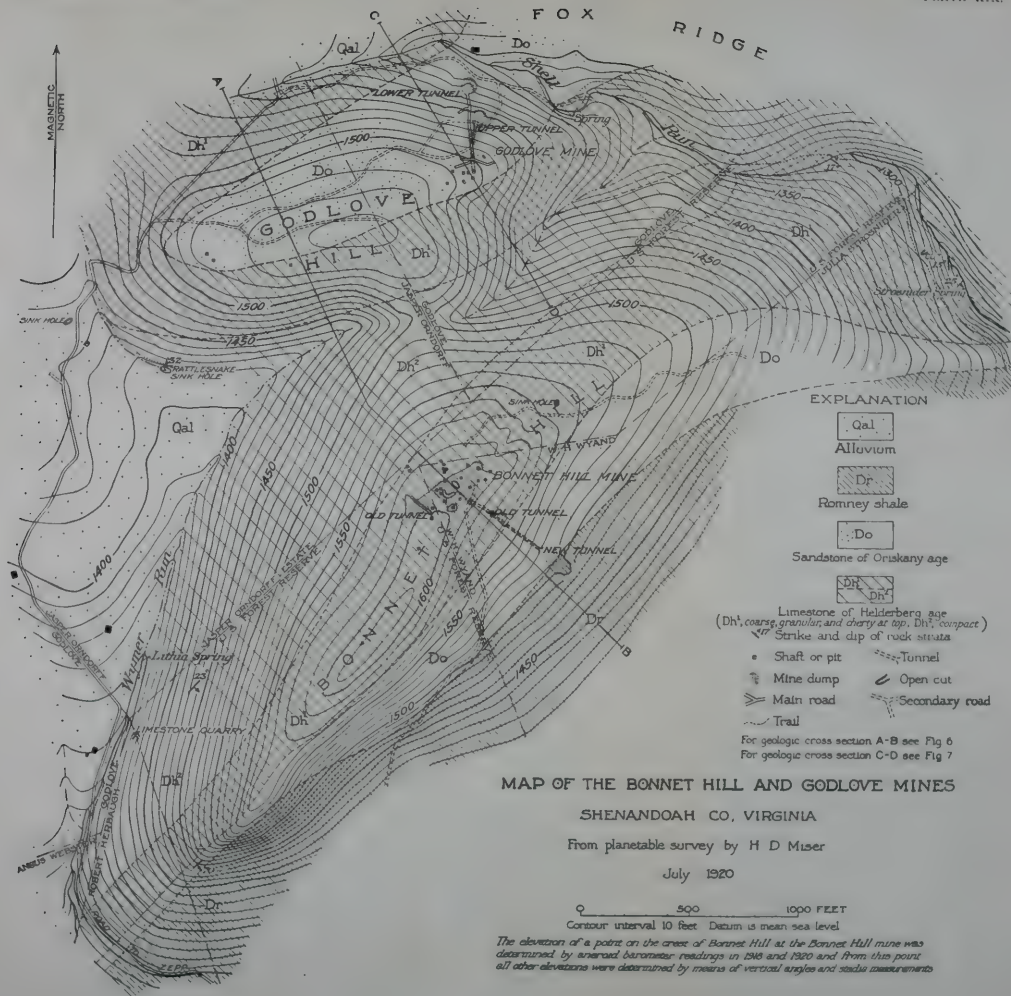
An inclined tunnel 20 feet long and a small pit were made about 15 years ago on the west slope and near the crest of the ridge. Both of them were made in sandstone beds in the Oriskany formation and the tunnel followed one or more of the beds. They revealed some manganese ore as thin veins but the quantity of it was small, as is indicated by the fact that only 200 pounds of ore was obtained.

BONNET HILL MINE.

Location and geography.—The Bonnet Hill mine is 2 miles southwest of the Mineral Ridge mine, 1 mile northwest of Zepp, 8 miles west-northwest of Strasburg, and 10 miles north of Woodstock. It is on Bonnet Hill, a low northeastward-trending ridge which is on the northwest side of Cedar Creek Valley. This valley trends northeastward and lies between Sluice and Great North mountains on the northwest and Little North Mountain on the southeast.

Bonnet Hill extends northeastward from Wymer Run to Shell Run, a distance of 5,000 feet and attains an elevation of 1,610 feet above sea level or about 330 feet above Wymer Run at the southwest end of the ridge and 360 feet above Strosnider Spring at the northeast end of the ridge. The crest is straight and is narrow southwest of the mine but the part of the crest at the mine and northeast of the mine is rather broad. A small sinkhole occurs on the crest 500 feet northeast of the mine. Godlove Hill, which is a much shorter ridge with an elevation of 1,540 feet above sea level, lies northwest of Bonnet Hill. Fox Ridge, which is S-shaped, is north of Shell Run and is opposite both Bonnet and Godlove hills. (See fig. 4 and Plate XX.)

Shell Run is a small perennial stream and is fed by two springs within the area that is represented on the accompanying map (Plate XIX), one being the Strosnider Spring and the other an unnamed spring at the northeast end of Godlove Hill. Wymer Run is perennial below Lithia Spring but is of small size. The permanent groundwater level in Bonnet Hill is lower than the lowest mine opening, which is a tunnel at an elevation of 1,515 feet above sea level, or 95 feet below the highest point on the crest of the hill. The groundwater level is perhaps 150 feet or more below the crest of the ridge at the mine.



History and production.—The Bonnet Hill mine was first worked in 1848 by William Remsen but no ore was shipped from it at that early date. It was next operated by C. M. Clay under the trade name U. S. Manganese & Mineral Co., beginning in 1916 and ending in the spring of 1919. He, together with Dr. S. M. Black, had leased the mining rights from the John S. Peer heirs, who at that time owned the agricultural rights. His production before the first visit in September, 1918, was 300,000 lbs. of ore and his entire production is reported to have been 7 carloads, all of which was high-grade chemical ore. Two carloads of this were shipped to the National Carbon Co., of Cleveland, Ohio. Beginning in July, 1919, the mine was operated by J. Carson Adkerson, who assumed the lease of Mr. Clay and Dr. Black. But since February, 1920, it has remained idle on account of litigation over the mining lease. Mr. Adkerson's production consisted of 5 carloads of ore, of which four were shipped as metallurgical ore and one as chemical ore. The mineral right of the property on which most of the mine is located is said to be owned by W. H. Wyand, representing the Maryland Mining & Fruit Co., of Hagerstown, Md. The location of the boundaries of this and the adjoining properties is shown on the accompanying map (Plate XIX). From this map it is seen that the old tunnel on the west hill slope and several pits and shafts are in the U. S. Forest Reserve, on property formerly held in trust for the St. Lukes Hospital, of New York.

Workings.—The mine workings are on and near the crest of the ridge and are about equal distances from the north and south ends of the ridge. They consist of (1) several prospect pits largely in surface material 6 feet deep, with soft ore at the base, (2) several shafts 30 to 40 feet deep, (3) short irregular drifts running from the shafts, (4) an open cut, (5) two old tunnels, and (6) a new tunnel. Only one of the shafts and the drifts from it could be entered at the first time of visit (September, 1918), and none of the shafts and tunnels could be entered at the time of the last visit (July, 1920). One of the old tunnels is on the east slope at an elevation of 1,570 feet above sea level, or almost 30 feet below the crest of the ridge. The new tunnel is on the east slope at an elevation of 1,515 feet above sea level, or 85 feet below the crest. It is 300 feet long and trends west-northwest. The other old tunnel is on the west slope and is in the U. S. Forest Reserve.

Geology.—The manganese-ore deposit occurs in chert and clay that have been derived from the weathering of the uppermost beds of the Helderberg limestone, which are probably of the same age as the Becraft lime-

stone of New York. The residual chert forms the crest of the ridge at the mine and for several hundred feet northeast and southwest of the mine. The chert is both hard and soft, occurs in thick and thin layers, and is broken by many fractures. It in general has the same dip as does the limestone from which it was derived and as do the overlying and underlying rocks, but during the weathering of the limestone its layers have doubtless settled some and have thus been bent more or less. Some of the chert beds that were observed in the workings dip 45° SE. The average dip at the mine is, however, probably about 30° in this direction. (See fig. 6.) The clay that is associated with the chert is red and yellow in color. The depth to which the clay and chert extend is not known but it is perhaps 50 feet or more below the new tunnel.

Lower beds of the Helderberg limestone, probably 100 feet thick, which occur below the chert, are exposed at places along Shell Run at the northeast end of the ridge, over a large area a few hundred feet north of the mine and on the west slope of the ridge southwest of the mine. They consist of siliceous knotty dark-gray limestone and of massive dark-gray coarse-grained limestone, and they contain dense chert which occurs as lenses parallel with the bedding and as vein-like bodies that cut across the bedding. Fossils obtained from these beds are said by E. O. Ulrich to show that they are of the same age as the New Scotland limestone of Pennsylvania.

The limestone of New Scotland age is underlain by still lower beds of the Helderberg limestone which are equivalent in age to the Keyser limestone of Pennsylvania. They consist of compact blue limestone, much of which is laminated. Exposures of them are numerous on the west slope of the hill. Limestone has been quarried from the thickest and purest beds near Lithia Spring and has been burned into lime for local use.

The Helderberg limestone is overlain by Oriskany sandstone. This sandstone at the southwest end of the hill is about 45 feet thick, crops out as heavy ledges, dips 70° SE., and forms the crest of the hill for a distance of 200 to 300 feet. Between this locality and the new tunnel the sandstone does not crop out as ledges. This is due to the sandstone becoming much thinner, or to its becoming much softer than it is to the southwest. At and near the new tunnel the sandstone again crops out as massive ledges and forms a narrow bench on the upper east slope; the dip is probably about 30° SE., and the thickness is apparently about 100 feet. The sandstone forms the crest of the northeast end of the hill and has about the same thickness and dip as it does at the new tunnel.

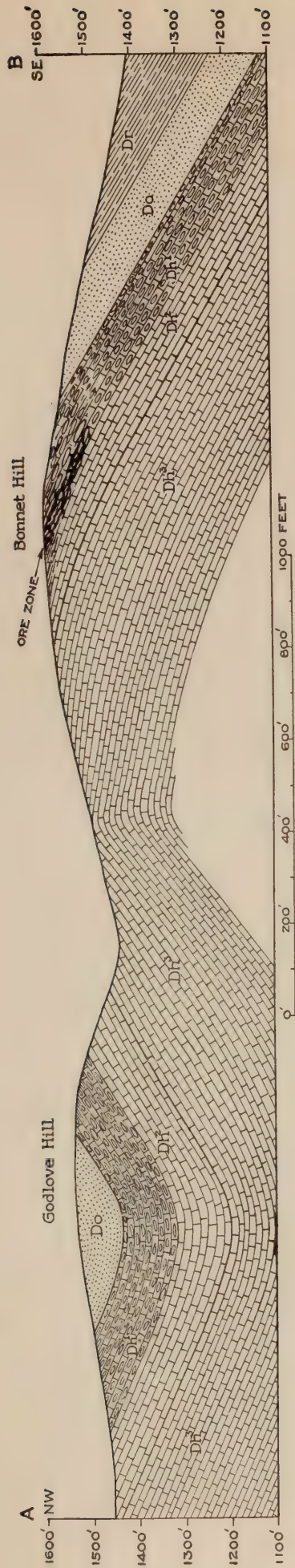


Fig. 6.—Geologic cross section through Godlove and Bonnet hills, Shenandoah County, along the line marked A-B on Plate XIX, illustrating the geologic structure and the occurrence of the deposit of manganese ore on Bonnet Hill. Dr, Oriskany shale; Do, Oriskany sandstone; Dh, Helderberg limestone (Dh,¹ cherty limestone; Dh,² coarse-grained limestone; Dh,³ compact limestone).

The Oriskany formation is overlain by the Romney shale. There are, however, no exposures of the shale within the area that is represented on the accompanying map (Plate XIX).

Stream wash occurs along and west of Wymer Run and there conceals the Helderberg limestone and the other rocks that have just been described. It consists of sandy loam and sandstone fragments as much as several feet in their longest dimensions, most of which have been carried by streams from Paddy Mountain. The thickness of the wash is not known.

The Helderberg limestone and Oriskany sandstone also occur on Godlove Hill where they occupy a shallow syncline, and between this hill and Bonnet Hill there is an anticline. Both the anticline and the syncline plunge northeastward so that the outcrop of Oriskany sandstone just north-east of Shell Run is S-shaped, which gives this form to Fox Ridge.

Manganese-ore deposit.—The ore body occurs, as previously stated, in chert and clay that have been derived by weathering from the upper part of the Helderberg limestone. Although the ore is irregularly distributed through the chert and clay, the general dip and strike of the ore body are the same as those of the chert and clay. The strike is therefore to the northeast and the dip is probably about 30° SE. The workings show that it occurs at or near the surface within a belt about 60 feet wide and 400 feet long, trending northeastward from the old tunnel that is on the west slope. The shafts southwest of the tunnel in the U. S. Forest Reserve failed to discover ore but further prospecting will perhaps show that the ore-bearing belt is much longer than 400 feet. A cut has been made recently near the Strosnider Spring on the property of Mrs. Julia Strosnider. It penetrated a yellow rocky sandy loam and no manganese minerals were found. It is, however, reported that manganese ore was found at this locality many years ago.

The shafts at the mine followed workable ore to a depth of as much as 40 feet below the surface and the new tunnel revealed ore at an elevation of about 95 feet below the highest point on the crest of the ridge. How much deeper the ore extends is not known but it will perhaps extend at least 50 feet below the new tunnel.

The ore-bearing zone penetrated by the shafts consists of chert, clay, and ore, and lies parallel with the bedding of the chert and clay. Where it was seen by the writers in one of the shafts it was several feet thick. Mr. Adkerson says it averages 8 feet thick in the shafts. The zone was just being penetrated in the new tunnel when work was discontinued there.

At places the pure ore makes up by weight more than half of the zone and some of the larger pockets yielded as much as 6,000 lbs. of pure ore. The ore has replaced the chert and clay. This is illustrated by a specimen which shows the complete replacement of a fragment of chert, except some of the siliceous parts of the included fossils. (See Plate XVIII.)

The ore consists of pyrolusite and psilomelane, mostly the former. The pyrolusite is bluish black in color and is granular and most of it becomes an impalpable powder when it is rubbed between the fingers. The psilomelane is black and steel blue in color and some of it has botryoidal surfaces. Some minute fractures in it contain crystalline pyrolusite showing that such pyrolusite was formed later than the psilomelane. Some of the ore is very siliceous and hard and is known as hard lump ore. Analyses of the soft blue and hard lump ores are given in the accompanying table.

Mining and preparation of ore.—The ore that has been marketed in recent years was mined by means of shafts as much as 40 feet deep and irregular short drifts that were run from the shafts. Some of the workings were very irregular combinations of shafts, short tunnels, and drifts, following the richer streaks. The ore was hand sorted in the workings to free it as far as possible from the clay and chert, hand picks being used to free the ore and dust pans being used to catch the soft ore. It was then raised to the surface by hand windlasses. Mr. Adkerson made the new tunnel with the intention of mining the ore in drifts and in overhand stopes at its west end but work in the tunnel was discontinued before any mining was done.

The ore that was marketed by C. M. Clay was allowed to dry as much as possible on the surface and some of the harder ore was crushed in a Jeffries limestone crusher. It was then sized by screens with 8, 24, 40, 60, and 80 mesh to the inch and the different grades thus obtained were put in barrels and shipped separately. The ore that was marketed by Mr. Adkerson was not treated except by handpicking.

ST. LUKES HOSPITAL TRACT.

A tract of land on Bonnet Hill, formerly held in trust for St. Lukes Hospital of New York but recently bought by the Government as part of the Potomac Forest reserve, is crossed by the ore horizon and has been prospected to some extent by parties who developed the adjoining Bonnet Hill mine. The location of the openings is shown on Plate XIX, and the description of the property is included with that of the Bonnet Hill mine, on preceding pages.

Analyses of manganese ore from the Bonnet Hill mine.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Manganese (Mn)	55.93	59.53	54.40	57.42	57.57	57.48	57.23	57.32	57.52	57.34	57.07	52.38	50.31	49.58
Iron (Fe)	1.27	.10	1.00	.72	.31	.81	.63	.72	.73	.81	.72	.39	.72	1.87
Phosphorus (P)		.199										.141	.078	
Silica (SiO ₂)	5.90	.97	5.95									11.86	14.12	15.75
Baryta (BaO)			2.98											.36
Manganese dioxide (MnO ₂)	88.20		86.50											78.66

- 1. Analysis of sample of soft blue ore. Alexander Fleming, analyst.
- 2. Analysis of sample of soft blue ore. Gulick-Henderson Co., analysts.
- 3. Analysis of carload of ore that was attached and stored at Strasburg in March, 1920. Alexander Fleming, analyst.
- 4-11. Analyses of barrel lots of soft blue ore that were shipped by C. M. Clay. Gulick-Henderson Co., analysts.
- 12-13. Analyses of samples of hard lump ore. Gulick-Henderson Co., analysts.
- 14. Analysis of sample of hard lump ore. Alexander Fleming, analyst.



(A) Lower part of Cedar Valley, looking north from near Zepp. Bonnet Hill at right and Godlove Hill in center carry manganese ore deposits. Sluice Mountain at left, cleft by Paddys Run Gap.

(By courtesy of W. H. Wyand.)



(B) Upper part of Cedar Valley, looking south from near Zepp, showing numerous ridges composed of Devonian sandstone and chert, some of which carry manganese ore deposits. Capola and Tea mountains in middle distance and Little North Mountain in left distance.

(By courtesy of W. H. Wyand.)

GODLOVE MINE.

Location and geography.—The Godlove mine is on the northeast end of Godlove Hill, a quarter of a mile north of the Bonnet Hill mine, $1\frac{1}{4}$ miles northwest of Zepp, 8 miles west-northwest of Strasburg, and 10 miles north of Woodstock. Godlove Hill is just south of Shell Run, a small perennial eastward-flowing stream and is between Bonnet Hill to the southeast and Sluice Mountain to the northwest. The hill is about a quarter of a mile wide and half a mile long and attains an elevation of about 1,540 feet above sea level or 170 feet above the spring on Shell Run at its northeast end. The crest is broad and the slopes are fairly steep though the northwest slope is less steep than the others. Two sinkholes occur at the southwest end of the hill. One of these is here named the Rattlesnake Sinkhole. Fox Ridge, which is S-shaped, is north of Shell Run opposite Godlove Hill. (See Plate XX.)

Water was, so far as known, not found in any of the mine workings. This means that the groundwater level is lower than the workings. Drinking water for the miners is obtained from the spring at the northeast end of the hill.

History and production.—The mine was first worked about 75 years ago by Joel Williams, who mined and marketed considerable ore which was hauled to Winchester, Va., a distance of 25 miles, for shipment. It was next worked by Cline and Capon 35 to 40 years ago and by Scott Roach about 30 years ago, though they did not ship any ore. C. M. Clay and Dr. S. M. Black, the next operators, worked the mine at times from 1915 until 1918 under the trade name U. S. Manganese & Mineral Co., and they are reported to have mined and shipped 3 or 4 carloads of ore, all of which was used for chemical purposes. The Kaylor-Fleming Manganese Co. next leased the property and in April, 1920, began the driving of the lower tunnel. In August, 1920, ore was found in paying quantities at a distance of 310 feet from the portal. Since then 50,000 pounds of ore for chemical purposes has been marketed.

The property on which the Godlove mine is located is owned by Mr. and Mrs. Riley Godlove, and the southwest part of the hill is on the Jasper Orndorff estate. The line between these two properties is shown on the map (Plate XIX).

Workings.—The mine workings, which consist of several shafts and two tunnels, are on the crest and northwest slope of a northeast point of Godlove Hill. The shafts are reported to be as much as 55 feet deep and

drifts were driven from them following the ore. The shafts are on and near the crest of the point of the hill. The portal of the upper tunnel occurs on the north slope at an elevation of 1,464 feet above sea level or about 70 feet above Shell Run at the house that is shown on the map (Plate XIX). The tunnel extends in a southward direction and is 185 feet long and from it drifts and inclines aggregating about 150 feet in length were made.

The portal of the new tunnel, which was being made at the time of visit (July, 1920), occurs at an elevation of 1,427 feet above sea level or about 30 feet above Shell Run to the north. The tunnel at that time was 210 feet long and since then it has been extended 100 feet farther. It has a general course of a few degrees east of south. Short cross cuts were made on either side of it at a distance of 58 feet from the portal. At a distance of 310 feet the tunnel struck one of the inclines that had been made from the upper tunnel and at this point drifts were run both to the southwest and northeast. The plan of the lower tunnel as it is represented on the map (Pl. XIX), is taken from a map that was furnished by Alexander Fleming, of the Kaylor-Fleming Manganese Co.

Geology.—The manganese-ore deposit occurs in Oriskany sandstone, which forms most of the crest of Godlove Hill. The outcrop of the sandstone is a belt which extends from the southwest point of the hill north-eastward across Shell Run. The outcrop at the mine where it is widest is about 600 feet. There are no ledges of this sandstone showing on the surface though there are numerous boulders, and the sandstone has, of course, been penetrated by the workings. The sandstone is massive and yellow and is probably 100 feet or more thick. Some layers contain small quartz pebbles, some contain casts of fossils, and most of it is soft enough to be mined with a pick, but some layers are very hard.

The Helderberg limestone, which underlies the Oriskany, is exposed at places on the southeast slopes of the hill between Rattlesnake Sinkhole and Shell Run. The high point adjoining the saddle which connects Godlove and Bonnet hills, is formed by chert that has been derived from this limestone. This limestone is also the surface formation on the southwest end and on a part of the northwest slope of the hill, though the limestone is there concealed by soil and by fragments of sandstone and chert. The Oriskany and other rocks in Godlove Hill lie in a syncline which trends and plunges northeastward. No dips could be measured by the writers on the sides of the syncline except at the Rattlesnake Sinkhole where the rocks dip 32° N.; the dips of the rocks at other places are perhaps 30° or

35° toward the middle of the syncline. (See fig. 7.) The dips that could be measured in the lower tunnel, which is mostly near the middle of the syncline, did not exceed several degrees and their directions differed at different places, but the dip at the end of the tunnel is said to be about 35° NW.

Manganese-ore deposit.—The manganese-ore deposit occurs on the southeast side of the above-described syncline and is in fractured sandstone near the base of the Oriskany formation and in a bed of clay 4 or 5 feet thick which is in the lower part of the sandstone. The clay is probably residual from a bed of limestone which once occupied the position that is now occupied by the clay. There are no outcrops revealing the manganese ore at the surface. The only thing at the surface to indicate the presence of metallic oxides at the locality is the occurrence of a comparatively small quantity of iron oxide in some of the sandstone fragments on the surface.

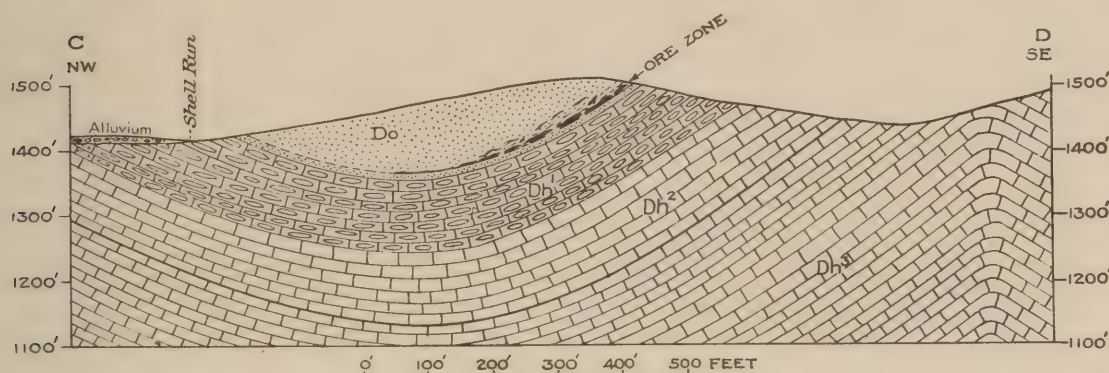


Fig. 7.—Geologic cross section through Godlove Hill, Shenandoah County, along the line marked C-D on Plate XIX, illustrating the geologic structure and the occurrence of the deposit of manganese ore at the Godlove mine. Do, Oriskany sandstone; Dh, Helderberg limestone (Dh¹ cherty limestone; Dh², coarse-grained limestone; Dh³ compact limestone).

The extent of the deposit has probably not been determined fully as the mine workings all occur within a north-south belt 400 feet long and 200 feet wide. The bulk of the ore mined before 1920 is said to have been found in one of the inclines made from the upper tunnel. One pocket of solid ore encountered there is reported to have been 4 feet thick. The tunnel was entered by the writers in September, 1918, but very little ore could be seen at that time. One shaft 55 feet deep with a drift at a depth of 30 feet which was entered by the writers, penetrated sandstone, and although very little ore was to be seen at the time of visit, some 4 or 5 tons

—enough to pay for making the shaft and drift—are said to have been obtained. Another shaft 24 feet deep, also with short drifts, was entered. It penetrated fractured sandstone and revealed a very small amount of manganese ore. Veinlets of manganese oxide were found in the broken sandstone at a distance of 58 feet from the portal of the lower tunnel and these were followed by means of short cross-cuts. From them only about 100 pounds of manganese oxide was obtained and handpicked from the sandstone. The quantity was therefore too small to be minable. Workable ore was, however, found at the south end of the lower tunnel where it is said by Mr. Fleming to occur as lenses as much as 2 feet thick in a bed of red clay 4 to 5 feet thick that lies between the two beds of sandstone. The clay and sandstone are said by him to dip about 35° NW. The lenses are said to be solid ore but some ore occurs intermixed with the associated sandstone.

Three shafts have been made on the Jasper Orndorff estate on the southwest part of the hill, and although they did not produce manganese ore in commercial quantity they revealed the presence of manganese oxides. Of these the shaft farthest east penetrated chert which is residual from the Helderberg limestone and the other two penetrated friable sandstone beds in the Oriskany. Since the time of visit this estate has also been leased by the Kaylor-Fleming Manganese Co., which has made a tunnel 275 feet long on the part of the property on Godlove Hill.

The ore consists of pyrolusite with a small amount of psilomelane. The pyrolusite is bluish black in color and is fine grained, and much of it is so soft that it becomes a fine powder when it is handled. All of the ore that was observed on the surface and in the workings at the different times of visit was associated with sandstone and some of it contained sand grains. The relations of the ore to the sandstone show that it has replaced the sandstone.

Analyses of manganese ore from the Godlove mine.

	1	2	3	4	5	6
Manganese (Mn)	60.30	58.60	62.00	53.34	58.16	54.40
Iron (Fe)	.06	.14	.06	.78	.29	.57
Phosphorous (P)	.233	.232	.175	.....	.....	.....
Copper (Cu) .....	.....	.....	.....	.....	.....	.01
Silica (SiO ₂)	.62	1.46	.....	6.55	.70	5.20
Baryta (BaO) .....	.....	.....	.....	3.34	3.41	3.50
Manganese dioxide (MnO ₂) .....	.....	.....	.....	84.37	91.99	.....

- 1-3. Analyses of samples. Gulick-Henderson Co., analysts.
4. Analysis of average sample from 5 or 6 tons of ore from the lower tunnel. Alexander Fleming, analyst.
5. Analyses of lump ore from lower tunnel. Alexander Fleming, analyst.
6. Analysis of ore from lower tunnel. Alexander Fleming, analyst.

Mining and preparation of ore.—The ore has been mined by hand in shafts and tunnels and so far as known all of the marketed ore was hand-picked. Experiments have been made recently with various concentrating devices to remove the sand from the sandy ore which forms a large part of the output of the mine.

RHESA A. ORNDORFF PROSPECT.

The Rhesa A. Orndorff prospect is an old tunnel on the north side of Trout Run, in the southwest end of the hill that lies southwest of Bonnet Hill, $11\frac{1}{2}$ miles southwest of Zepp postoffice. (See fig. 4.) The tunnel was made 30 years ago by Harry Fahrney and Dr. Haffer, of Hagerstown. It enters the hill a few feet above Trout Run and is in chert which strikes N. 15° E., and dips 35° to 40° SE. (See fig. 8.) The tunnel follows

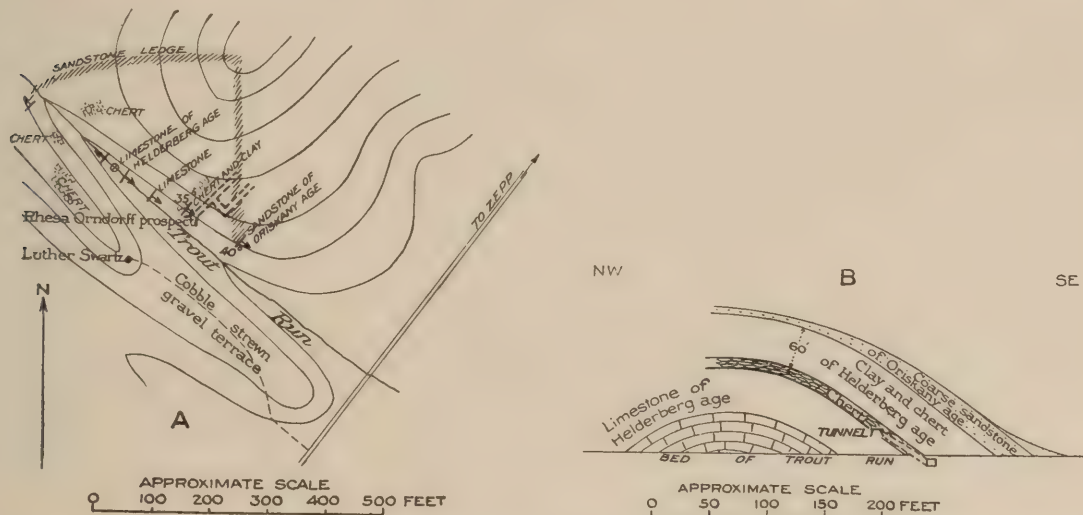


Fig. 8.—Sketch map (A) and section (B) of the Rhesa A. Orndorff prospect, Shenandoah County.

the strike of the mineralized zone 60 feet, and a lower parallel drift, reached by a slope 35 feet long down the dip of the bed, is said to go in 200 feet, but it was filled with water at the time of visit. Seventy tons of manganese ore is said to have been removed from the tunnel and placed on the dump at the edge of the run, but at the time of visit most of it

had been washed away by the stream. The ore is in chert beds 1 to 2 feet thick separated by thin sandy clay beds. At the entrance the ore is chiefly iron oxide but in depth it was reported to be chiefly manganese oxide which filled crevices and seams in the chert and partly replaced it. As determined by an examination of fragments on the dump the manganese ore consists of pyrolusite with some iron oxide in part intimately mixed. No analyses of the ore are available but according to report it contains 1.3 per cent or more of phosphorus. The presence of so much phosphorus would prohibit the use of the ore for metallurgical purposes and the large quantity of iron oxide in it, if it could not be separated from the ore, would bar its use for chemical purposes. W. H. Wyand, of Hagerstown, representing the Maryland Mining & Fruit Co., holds an option on the mineral rights to the property.

SWARTZ PROPERTY.

The low hill southwest of the Rhesa A. Orndorff prospect, owned by M. Luther Swartz, is composed of Oriskany sandstone underlain by Helderberg limestone, and the surface is covered with chert fragments more or less impregnated with manganese oxide. No prospecting had been done, so the property was not critically examined. The mineral right is held under option by W. H. Wyand, representing the Maryland Mining & Fruit Co.

MARY ORNDORFF PROSPECT.

The Mary Orndorff prospect is on a low ridge next southwest of the Swartz property and 2 miles northeast of Van Buren Furnace. A shaft 16 feet deep on the upper west slope of the ridge at an elevation of 70 feet above its base and a nearby cut were made by C. M. Clay. They expose chert and sandy clay which yielded a small quantity of manganese oxide in which there is considerable sand. W. H. Wyand, representing the Maryland Mining & Fruit Co., has secured the option on the mineral rights from Mary Orndorff, the owner.

CAPOLA MOUNTAIN MINE.

The Capola Mountain mine is on the southwest end of Capola Mountain near the head of Cedar Creek Valley, about half a mile south of the old Van Buren Furnace. (See fig. 4.) It was operated about 1880 by the Van Buren Furnace Co. under Mr. King, who is said to have shipped some manganese ore and several carloads of iron ore. The mountain has since been included in the U. S. Forest Reserve. Some legal matters in

connection with the acquisition of the property by the Government have prevented work at the mine in recent years. (See Plate XX.)

The openings comprise an open cut along the southwest backbone of the ridge over a distance of about 400 feet, a shaft, and a tunnel. (See fig. 9.) The lowest opening is 250 feet above the southwest base of the mountain,

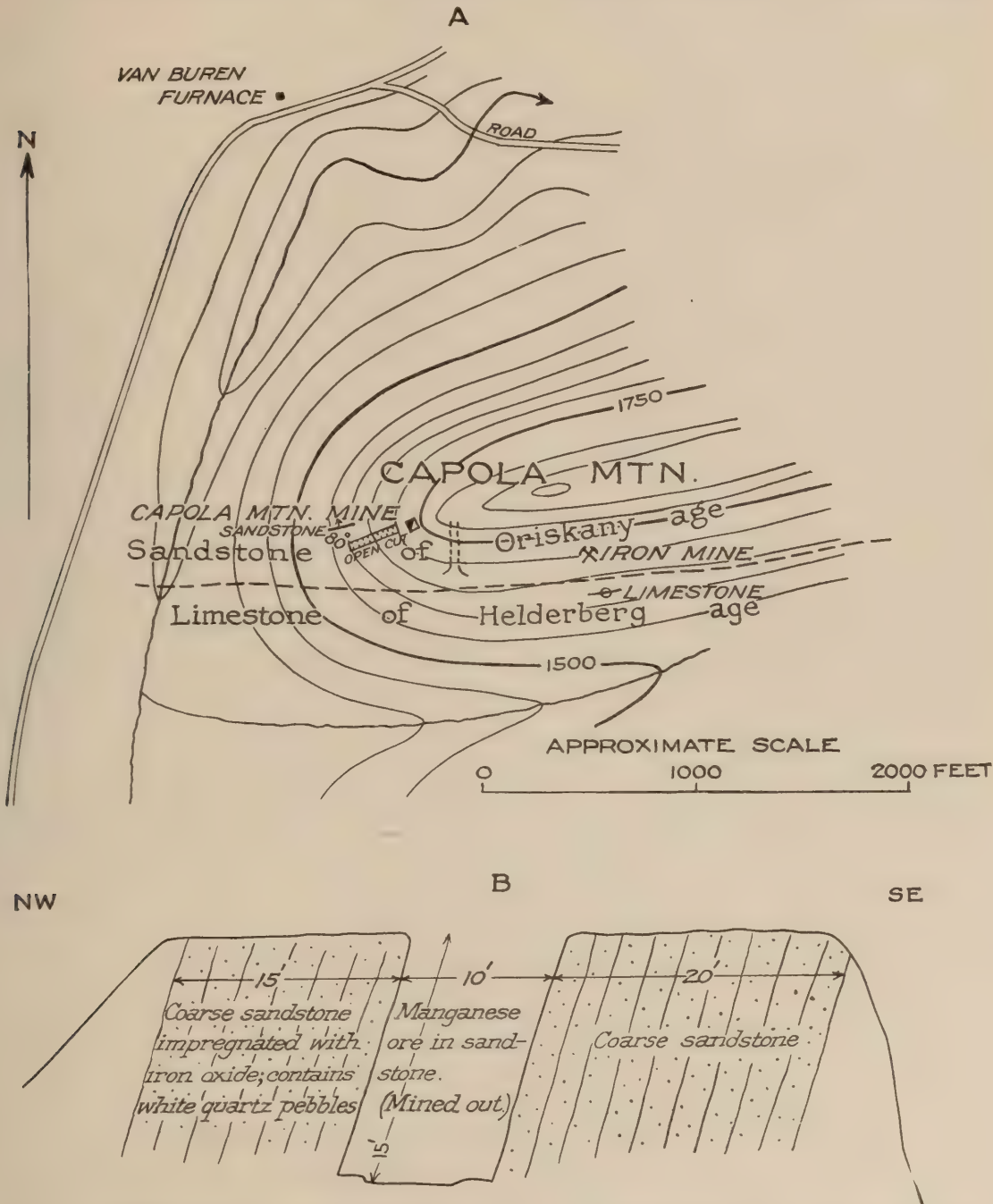


Fig. 9.—Sketch map (A) and section (B) at the Capola Mountain mine, Shenandoah County.

from which an open cut 10 to 14 feet wide and about 20 feet deep but partly filled, extends almost continuously up to the shaft, 100 feet higher vertically. The shaft, which is 10 feet square, is 67 feet deep, the upper 37 feet being reported to be in manganese-bearing sandstone. All the openings are in a gray fossiliferous pebbly sandstone of Oriskany age which strikes N. 80° E. and dips 65° to 80° N. Although most of it is hard and forms outcropping ledges, the mineralized portion is friable. The pebbles in it are of well rounded milky white quartz from the size of rice up to 1 inch in their longest dimension. (See Pl. XXXI.) The ore-bearing zone is from 8 to 14 feet wide parallel with the bedding of the sandstone. The manganese ore consists of pyrolusite and some psilomelane and occurs in the sandstone as small crevice fillings and replacement pockets. All of the pockets that were visible are small in size. The ore in them and in the fragments on the surface contains more or less sand, indicating that it has replaced the sandstone. Higher on the crest of the mountain there are shallow pits from which iron ore was obtained for the Van Buren Furnace and on the southeast slope a tunnel at 2,100 feet above sea level is reported to be 100 feet long and to have passed through barren sandstone into iron ore.

LITTLE NORTH MOUNTAIN PROSPECT.

Manganese ore is reported to occur along the northwest slope of Little North Mountain at many places. Only one prospect was visited. It is at 1,780 to 1,850 feet above sea level on a high knob below the summit of the mountain north of the Fetzner Gap road to Woodstock, and was opened by Early Orndorff. Psilomelane fills crevices in brecciated Clinch quartzite, which dips 20° to 35° SE. into the mountain and is evidently part of a local syncline west of the main summit. Large blocks of quartzite in the talus below contain considerable manganese in seams, but not in commercial quantity.

LIBERTY FURNACE TRACT.

The Liberty Furnace property is a tract covering 13,000 acres of mining rights in the mountainous area 8 to 10 miles northwest of Edinburg. (See fig. 10.) It is connected with Edinburg by a 3-foot gage railroad. The property is owned by the Joseph T. Jackson heirs, of Philadelphia, and prospecting for manganese has been done by Joseph Brenner and Theodore Cain. The iron furnace on the property has not been in blast since 1908. This and the Columbia Furnace near by were operated as early as 1812. There are numerous iron ore banks and pits on the property which furnished iron ore for the furnaces and which are still

said to contain an ample supply of such ore. Several of the openings are said to carry manganese ore, and three of them, High Head, Yellow Springs, and Gap Mountain, were examined by the writers and will be described below. A manganiferous iron prospect in Riffey Mountain, 3 miles northeast of Yellow Springs, was not visited. It is reported to be an open cut 300 feet long, 12 feet wide, exposing a 6-foot bed of manganiferous iron ore.

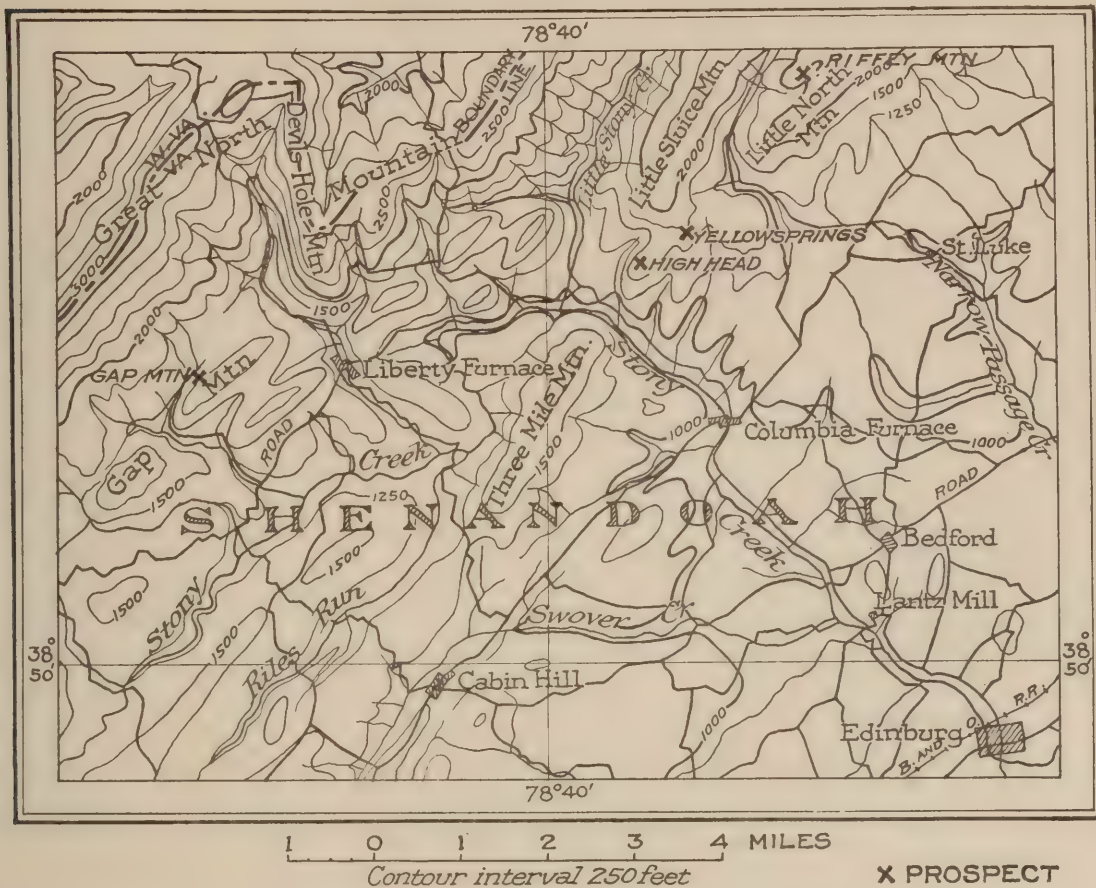


Fig. 10.—Sketch map showing the location of the manganese prospects near Liberty Furnace, Shenandoah County.

HIGH HEAD PROSPECT.

The High Head prospect is on the southwest point of a hill known as High Head, just north of Stony Creek, 7 miles northwest of Edinburg. (See fig. 10.) Prespecting has been done at this locality during the last few years for the owners, the J. T. Jackson heirs, of Philadelphia, and although some manganese ore had been discovered, none of it had been marketed before the time of visit (Sept. 10, 1918).

The prospect work consists of three or more shafts, an open cut, and a tunnel. The highest opening is a shaft which is at an elevation of 1,790 feet above sea level. (See fig. 11.) It was sunk to a depth of 50 feet largely in sandstone and yellow clay, and limestone is said to have been encountered in it. Soft pyrolusite was removed from the shaft but the quantity

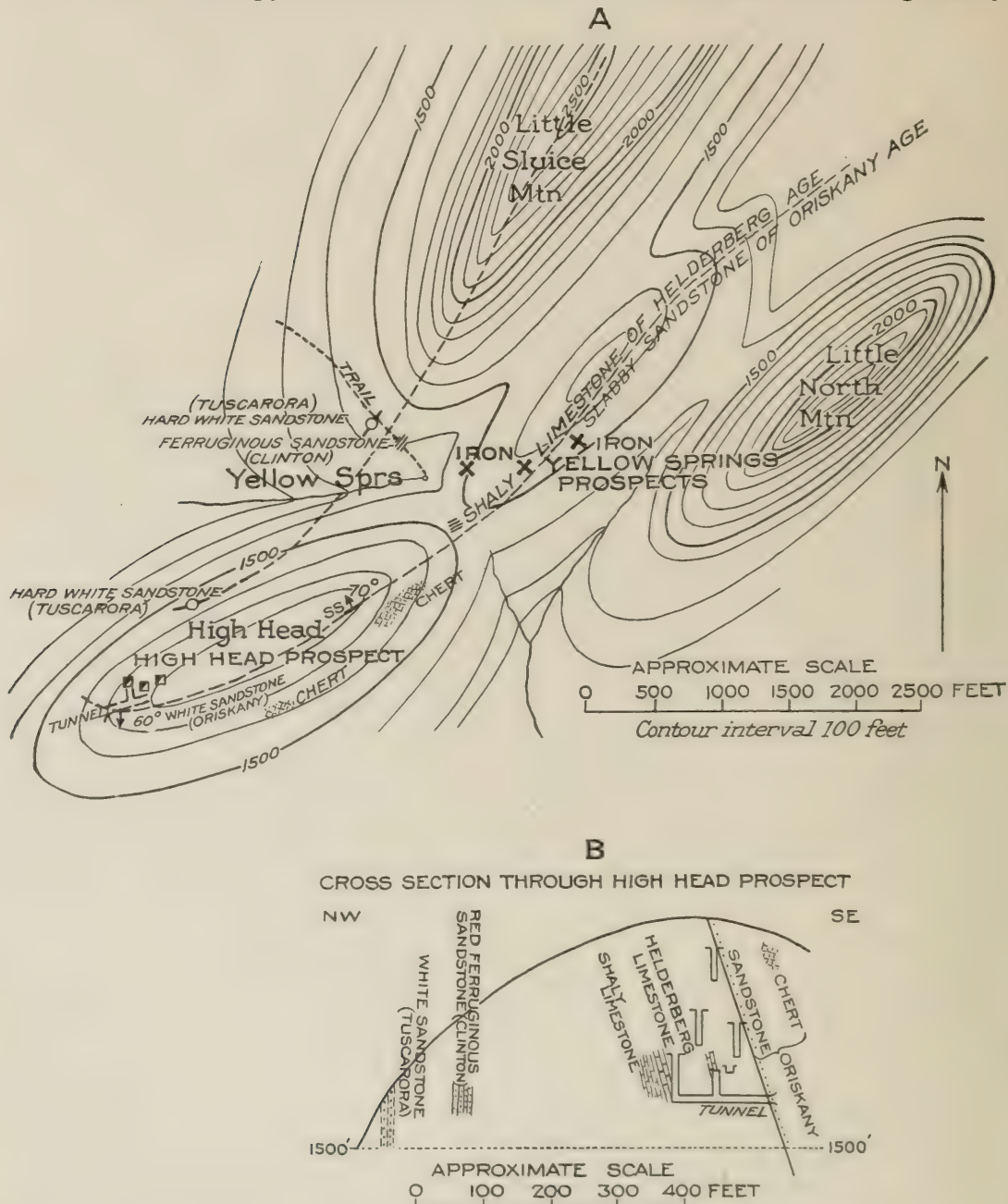


Fig. 11.—Sketch map (A) at the High Head and Yellow Springs prospects and a section (B) through the openings at the High Head prospect, Shenandoah County.

was apparently small. Another shaft lower on the slope was sunk to a depth of 40 feet in yellow clay and chert, but it yielded no manganese minerals except stains and minute fragments. A third shaft, 1,740 feet above sea level and 25 feet deep which was sunk in yellow clay and chert passing into limestone at the bottom, yielded a very small quantity of pyrolusite.

An open cut southeast of the lower shafts is 40 feet long and follows an ore-bearing zone of sand and soft sandstone about 7 feet thick that lies parallel with the bedding. The hanging wall of the cut is a heavy gray sandstone which dips 60° S., and is the same bed as that which forms the crest of High Head. Pyrolusite with some psilomelane occurs in this zone as a fissure-filling in the sandstone and also replaces some of the sandstone.

The lowest opening is a tunnel at an elevation of 1,710 feet above sea level. It follows an ore-bearing zone of sand and sandstone similar to that in the cut. This zone dips to the southwest and the sand, and sandstone in it contain irregular veins of pyrolusite which locally swell to 8 inches thick. It is overlain by sandstone and is underlain by cherty clay and yellow clay in which very little manganese oxide has been found. A cross-cut, which has been made through the clay, connects with the lower shaft. Gray granular limestone was encountered in the shaft at the end of the cross-cut. The few fossils obtained from this limestone and the associated clay were reported by E. O. Ulrich to be of Helderberg age and equivalent to the Becraft limestone of New York. The yellow clay and chert have obviously been derived from this limestone by weathering. The ore zone appears to be in soft sandstone between limestones of Helderberg age to the north and heavy coarse sandstone of Oriskany age to the south. The beds strike to the northwest at the lowest opening, and are apparently cut off by a fault on the west side of the mountain.

The plan proposed for the operation of the property was to mine from the tunnel, which is the lowest working, from the mouth of which a steep incline was to be built to the stream below at the foot of the mountain slope, where a log washer was to be installed.

The pyrolusite at this locality, as is indicated by the accompanying analyses, is apparently of good quality for chemical purposes but the quantity is small. Furthermore it is so soft that it is simply a compact powder, which means that if any of the pyrolusite is marketed as a chemical ore it would probably have to be separated by hand from the clay, chert, sand, and sandstone.

Analyses of ore from the High Head prospect.

	1	2	3	4
Manganese (Mn)	53.20	53.35	54.24	57.20
Iron (Fe)	.82	.68	.....	.....
Iron and alumina .....	.....	.....	2.08	1.62
Phosphorus (P)	.227	.222	.....	.....
Silica (SiO ₂)	1.87	4.79	3.92	5.06

- 1. Lump ore. Geo. C. Davis, Philadelphia, Pa., analyst.
- 2. Fine ore. Geo. C. Davis, Philadelphia, Pa., analyst.
- 3. Hard ore. Froehling & Robertson, Richmond, Va., analysts.
- 4. Soft ore. Froehling & Robertson, Richmond, Va., analysts.

YELLOW SPRINGS PROSPECTS.

The Yellow Springs tunnel, which was made 30 years ago in search of iron ore, is on the lower west slope of a ridge or foot hill of Little Sluice Mountain 7 miles northwest of Edinburg. It is at an elevation of 1,520 feet, trends S. 80° E., and is said to be 400 feet long. It was not entered by the writers, but the presence of yellow clay and sandstone on the dump indicates that it was driven through these materials. A porous brown iron ore that appears to contain a few per cent of manganese was obtained in considerable quantity in the tunnel and was placed on the dump. Another tunnel and more than a dozen pits and shafts were made at different places on this ridge to the northeast during the prospecting for iron ore but few of them were visited. The sandstone and sandy clay in which the ore zone occurs are above red ferruginous beds of the Clinton formation and are probably Helderberg or Oriskany in age.

GAP MOUNTAIN PROSPECT.

The Gap Mountain prospect is on the northwest slope of a low ridge known as Gap Mountain, which is 2 miles west of Liberty Furnace. Two tunnels were made many years ago at an elevation of 1,600 feet above sea level. One of these which was entered by the writers is more than 50 feet long, but the other had caved in. Both had been made in thin-bedded, fractured chert probably of Helderberg age. Thin laminated shaly limestones, apparently of Cayuga age, outcrop in the small valley northwest of Gap Mountain, and the ridge is capped by coarse heavy sandstone, probably of Oriskany age. Small plates of manganese ore occur with chert fragments in the dump and at some places psilomelane and manganite fill minute cracks in the chert fragments and have replaced small portions of some of the fragments. No manganese ore was shipped from this prospect.

SCOTT PROSPECT.

The Scott prospect is on the northwest side of Round Hill, 1 mile north of Toms Brook. (See fig. 12.) Iron ore was mined there in 1915, and J. D. Scott, of Toms Brook, has been recently prospecting the property for manganese. Round Hill is composed of chert derived from the Knox dolomite. The ore occurs as loose-textured, porous masses in chert and clay derived from the weathering of the dolomite. The ore seen was iron oxide with a core of pyrite. No manganese oxide was visible.

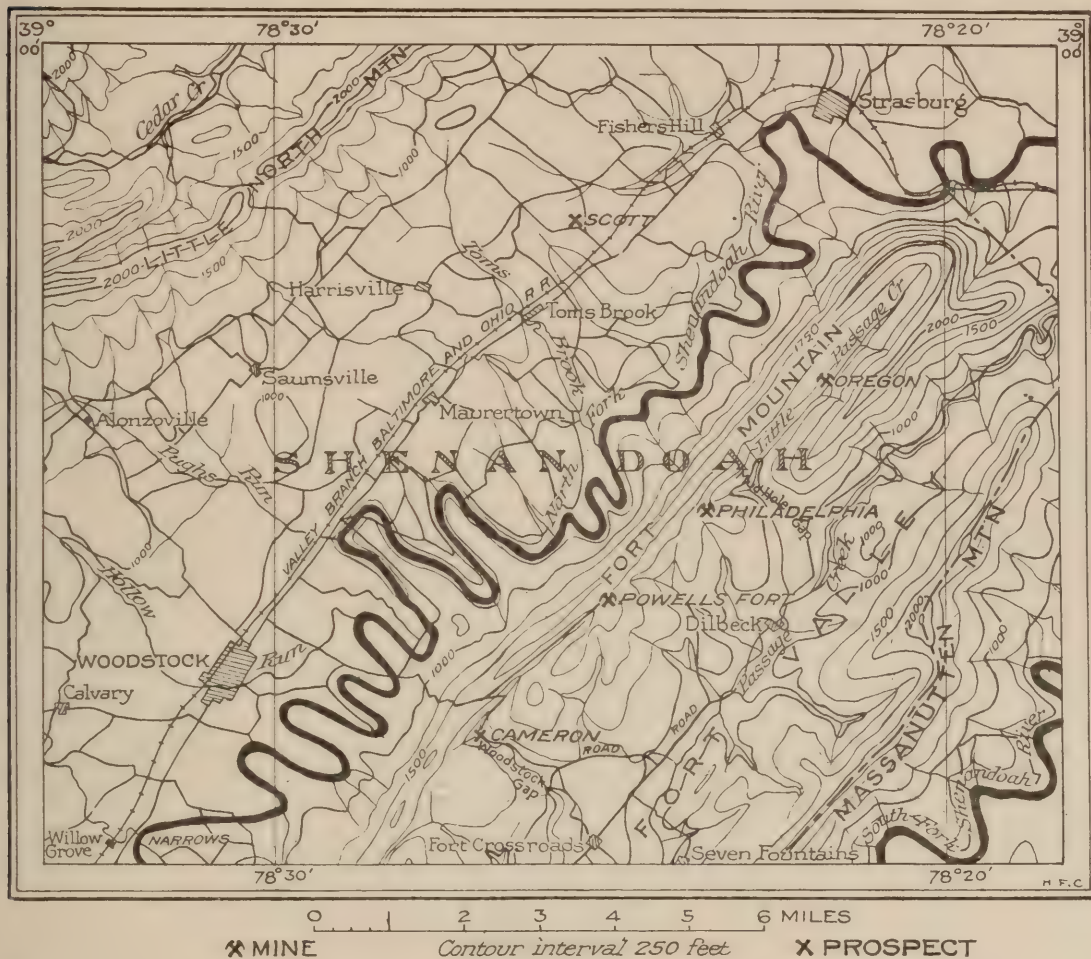


Fig. 12.—Map of a part of Shenandoah County, showing the location of the manganese mines and prospects east and northeast of Woodstock.

POWELLS FORT MINE.

Location and geography.—The Powells Fort mine, formerly called the Baltimore mine, is 6 miles due east of Woodstock in the first valley east of Powell Mountain, locally called Fort Mountain, the western ridge of Massanutten Mountain. (See fig. 12.) It is 2 miles north of the Wood-

stock-Seven Fountains road, from which it is reached by a wagon road on the east slope of Fort Mountain. The mine is in the valley bottom of Mine Run, a small stream which heads between Fort Mountain and Green Mountain and flows northeastward in a gentle valley to a sharp gap in Green Mountain, through which it flows southeastward to join Passage Creek. (See Pl. XXI.) The elevation of the valley floor at the mine is 1,320 feet, about 500 feet below the top of Fort Mountain in this vicinity and 400 feet below the top of Green Ridge. Although the mine is near the head of the small valley, there is a considerable flow of water from springs and at present from the mine workings.

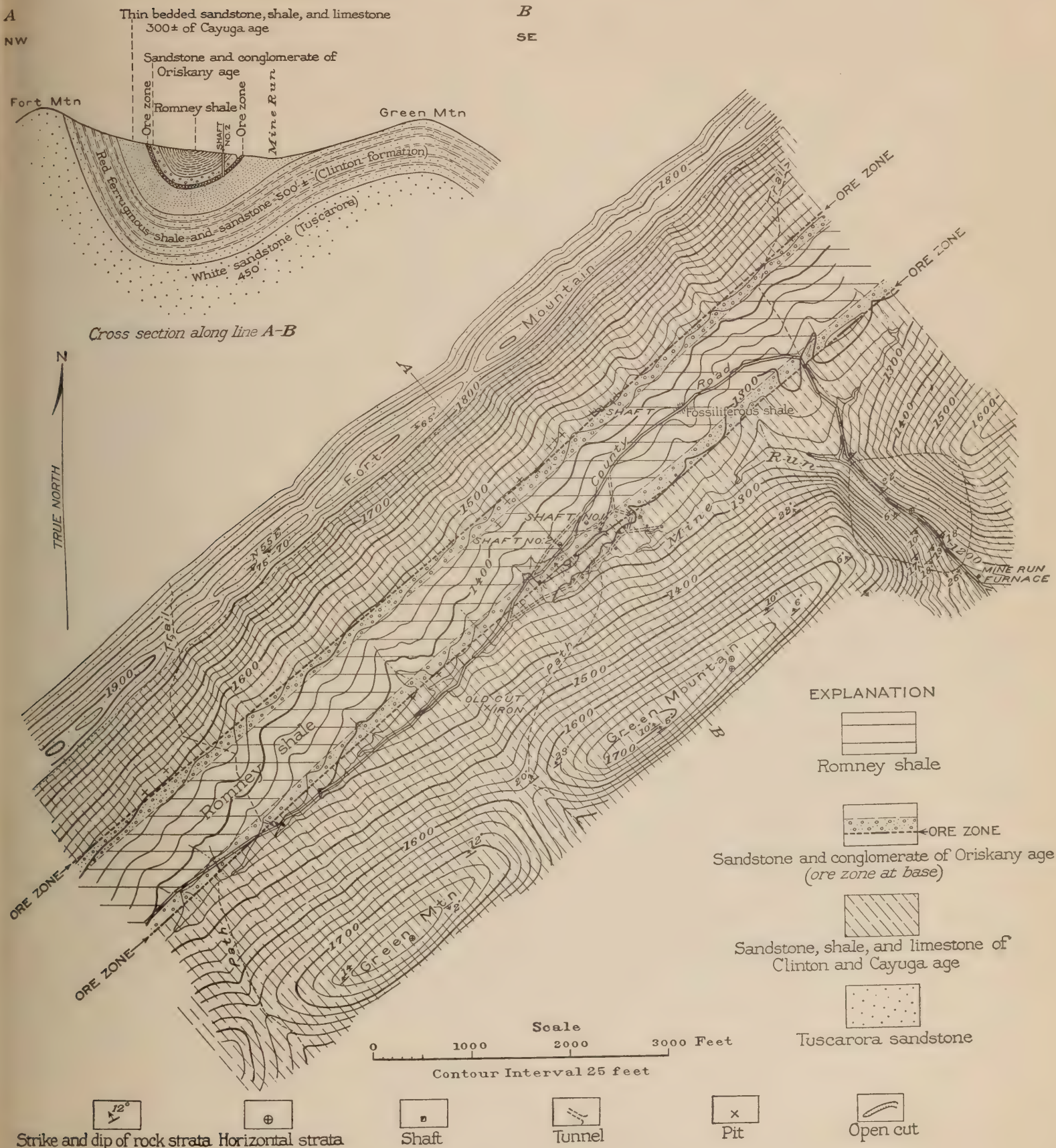
History and production.—The Powells Fort mine is reported to have been first operated about 1880 when it was worked in a crude way on a small scale at intervals for several years.¹ During this period about 1,000 tons of ore are said to have been mined and shipped. In 1885 the property, covering 531 acres, was purchased by the Manganese & Iron Co., of Baltimore, which renewed the equipment of engine, hoist, pump, etc., preparatory to active work. The company reported that there were two shafts (probably the inclined shafts of the present workings), 85 feet and 75 feet deep respectively, and a 40-foot drift on the property when it took possession. No record of the amount of work done by this company is available. The mine was reported to have been worked again in 1907 and 1908 but only in a small way. The property was later acquired by H. P. Binswanger, of New York, who operated the mine in 1915 and 1916 and shipped 135 tons of ore. In 1916 the mine was leased from the Binswanger heirs by the Stockwood Realty Corporation, of Woodstock, a subsidiary mining company of the National Carbon Company, of Cleveland, Ohio. This company, under the management of J. Carson Adkerson, mined and shipped over 1,000 tons of chemical ore in 1916, 1917, and 1918. The lease expired in 1919 and upon failure to agree on terms for renewal the mine closed down and has not since been operated.

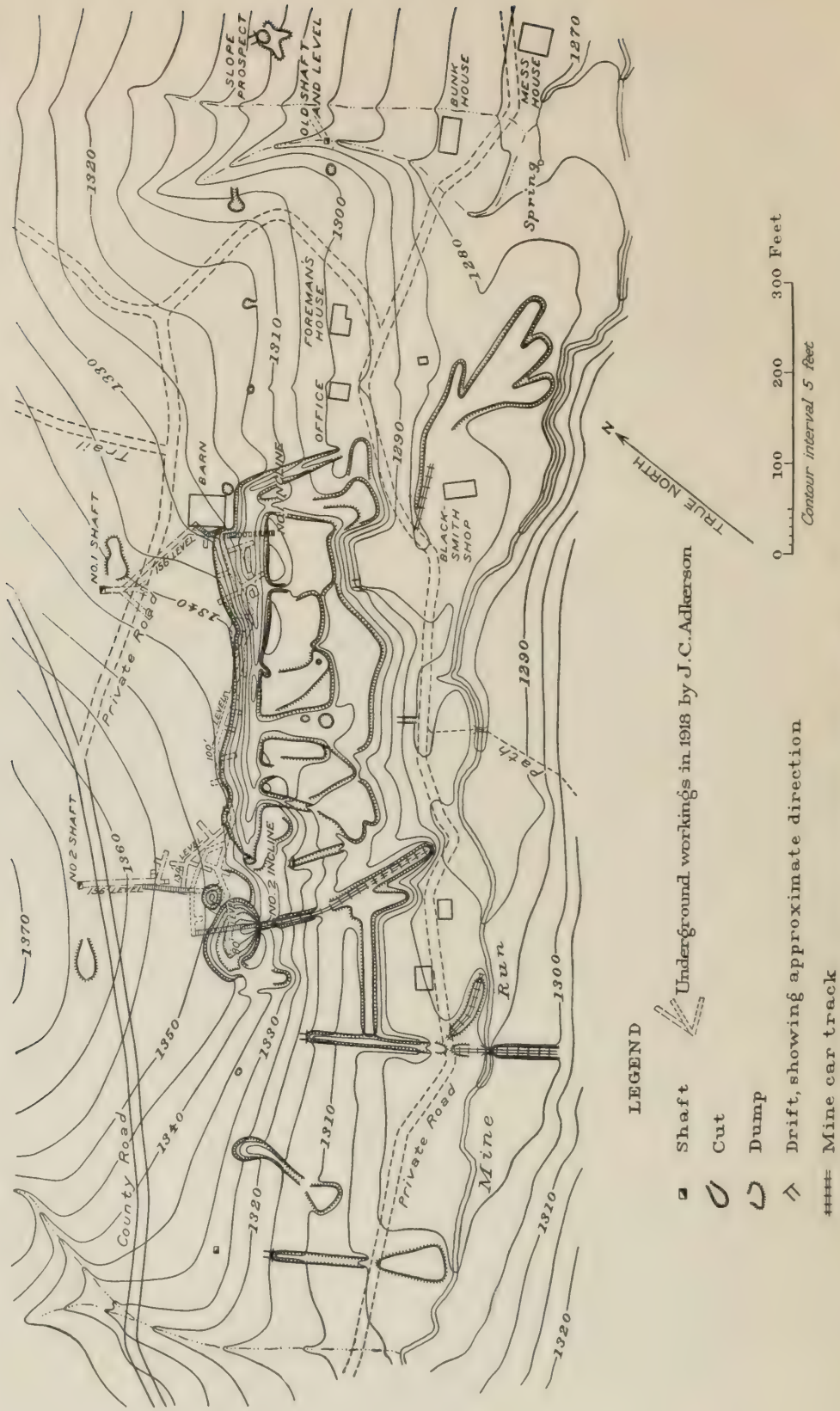
Workings.—The surface openings are indicated on Plate XXII, and the details of the underground workings are shown on Plate XXIII. As stated under history, underground mining from 2 inclined shafts has been done at times since 1885 and mining by open cut has also been carried on along the outcrops of the ore zone in the bottom of the valley. One open cut is con-

¹ The early history is in part taken from Weeks, J. D., Min. Res. of United States for 1885, U. S. Geol. Survey, 1886, pp. 324-5 and Holden, R. J., unpublished notes 1909, published in Bulletin 427 U. S. Geol. Survey, pp. 67, 68, 1910.

MAP AND CROSS SECTION OF MINE RUN VALLEY, SHOWING OUTCROP OF ORE HORIZON AND LOCATION OF POWELLS FORT MINE SHENANDOAH CO., VA.

From planetable survey by T.K.Harnsberger in 1915, with
modifications of geology by G.W.Stose.





MAP OF THE WORKINGS OF POWELLS FORT MINE

From planetable survey by T.K. Harnsberger, 1915,
with addition of underground workings by J. Carson Adkerson

tinuous for a length of 400 feet, and there is only one break of 50 feet unmined in a total length of 550 feet of open cut. The width of the cut is 30 to 50 feet and its depth is as much as 50 feet where tunnels have caved in. The open cut, and the tunnels therefrom, were abandoned because of trouble with surface waters, wet ground, and caving of workings, and in late years the mining has been entirely underground. The underground workings connect with two shafts, marked 1 and 2 on Plate XXII, and at time of visit the active workings were on the second (134-foot) level. Drifts on the upper (100-foot) level were driven southeastward toward the outcrop and on the second level northwestward to intersect the ore zone. All the workings are restricted to the eastern limb of the syncline. At the time of visit (Sept., 1918) the ore from both levels had nearly been worked out and robbing of pillars was in progress preparatory to abandoning the levels. The third (156-foot) level had been begun.

Besides the main workings there are numerous test pits along the outcrops of the southeast limb of the syncline and others along the northwest limb. A shaft on the northwest limb north of the present workings was sunk to a depth of 40 feet, from which drifting to the northeast and southwest extended about 80 feet. It is reported that three carloads of ore were obtained from these workings.

Geology.—The mine is located near the bottom of a syncline which encloses Oriskany sandstone and Romney shale in the center. (See Pl. XXI.) A vertical section of the rocks with which the deposits are associated is shown on the following page.

The northwest limb of the syncline is much steeper than the southeast. (See section on Pl. XXI.) The Tuscarora sandstone composes the crest of Fort Mountain and there dips 75° SE. The ore-bearing zone at the base of the Oriskany on the northwest limb of the syncline, crops out on the southeast slope of the mountain, 150 feet above the valley bottom, having about the same dip. The ore-bearing zone on the southeast limb outcrops in the bottom of the valley just west of the stream and has a northwest dip of 45° . The underlying thin and slabby sandstones compose the slope of Green Mountain to its summit, and the dip decreases to 10° near the crest and to horizontal at the top. Green Mountain is an anticline which is cut through in Mine Run and Woodstock gaps exposing the Clinton and Tuscarora formations, but the rocks of Cayuga age form its entire slope. A section across the valley is shown on Plate XXI.

Section of rocks at Powells Fort mine.

Age.	Name.	Thickness. Feet.	Description.
Devonian.	Romney shale.	300+	Fissile yellow to buff fossiliferous shale, black where fresh, containing fossils of Marcellus age.
	Oriskany sandstone (quartzite hanging wall of mine).	20	Hard granular sandstone and conglomerate of rounded milky-white quartz pebbles one-fourth to one-half inch in size. Weathers pitted and crumbly.
	Ore zone, possibly of Helderberg age.	10-20	Sandstone and clay breccia with pockets of ore. (Blue fossiliferous limestone, possibly of Helderberg age, reported exposed at this horizon near Seven Fountains.)
Silurian.	Rocks of Cayuga age.	300±	Fine buff to gray sandstone (foot wall in mine) in places highly impregnated with manganese oxide. Buff laminated sandstone weathering slabby and platy; probably includes some thinly laminated limestone (seen northeast of mine).
	Clinton formation.	500±	Buff to red fissile clay shale, thin-bedded buff to rusty sandstone, and red ferruginous sandstone.
	Tuscarora sandstone.	450±	Hard, white, thick-bedded sandstone or quartzite, thinner bedded and rust-stained in lower part. Forms crests of mountains.

Manganese ore deposits.—The manganese ore occurs in an irregular zone 10 to 20 feet thick beneath the massive quartzose conglomerate of the Oriskany. As exposed in the open cuts, shafts, and underground mine workings, it appears as a zone of breccia composed of partly disintegrated sandstone blocks in banded buff to red and purple sand with clayey streaks. Some parts preserve original bedding structure more or less disturbed and lenticular in arrangement. This breccia zone appears to be the result of caving and brecciation of sandstone beds from the solution of underlying limestones which probably occupied part of the space now filled with breccia. The broken sandstone blocks are enclosed in iron-stained sand and clay derived from the weathered limestone. Limestone is not exposed in the mine or at the surface in the vicinity of the mine, but is known to be interbedded with the sandstones of Cayuga age northeast of the mine.

The manganese oxide was deposited in the brecciated mass, filling the fractures and replacing the sandstone masses to a large extent, and occurs as irregular masses in pockets in the breccia. It also impregnates the underlying compact sandstone footwall in places to a depth of 10 to 15 feet by replacing some of the grains of quartz and forming a highly siliceous ore called by the miners "blue rock." Crystalline manganese oxide is also deposited in joint crevices in the hanging wall conglomerate, or quartzite as it is called by the miners, but does not occur there in minable quantity.

In the wall of the caved 40-foot shaft on the southeast slope of Fort Mountain, examined by the writer, there was a 12-foot capping of iron-cemented brecciated sandstone overlying hard brecciated sandstone containing small pockets of crystalline pyrolusite. The sandstone matrix in this exposure, which is on the northwest limb of the syncline, is harder than the ore-bearing rock in the workings on the southeast limb. The ore found in these test pits did not warrant mining on the northwestern limb.

The ore zone seems to thin out southwestward along the axis of the syncline, in which direction the fold rises, but is said to improve northeastward in the direction of the pitch. It is stated that larger masses of ore were encountered in the upper workings than in the lower, but that neither an increase nor diminution of ore content was noticed with depth.

The ore in the ore zone is almost entirely granular crystalline pyrolusite (manganese dioxide), and has been used largely for dry battery fillings. The oxide in the crevices of the hanging wall is also pyrolusite, although in open crevices it forms shiny, bladed crystals closely resembling manganite. (See Pl. XIV.) Some crystal surfaces are tarnished to a brassy color, resembling that of pyrite. The ore in the footwall appears from its color also to be pyrolusite, but it is so intimately mixed with quartz grains that it cannot readily be crushed and concentrated profitably. The footwall ore is said to run about 25 per cent silica and it is therefore too siliceous without concentration for most metallurgical purposes.

The physical characters and chemical composition of the pyrolusite from this mine have been described and discussed recently by Thomas L. Watson, State Geologist, and Edgar T. Wherry.¹ In his discussion of the origin of this mineral Watson says:

"The writer is fully aware of the prevailing view that pyrolusite crystals are pseudomorphous in origin, and that many pyrolusite crystals have the

¹ Watson, T. L., and Wherry, E. T., Pyrolusite from Virginia: Washington Acad. Sci. Jour., vol. 8, pp. 550-560, 1918.

form of manganite. The present study, however, of the material from the Virginia locality suggests the probability that the pyrolusite may be original; that is, it has a distinct crystalline form of its own, and is not secondary in the sense of being derived from manganite by dehydration and oxidation."

The crystalline ore is found mostly in solid chunks up to the size of a barrel. One mass 2 feet by 3 feet by 1½ feet was seen by the writers. Such solid lumps are shipped without milling and are said to run 90 to 92 per cent manganese dioxide, 3 to 4 per cent silica, less than 1 per cent of iron, and a trace of copper. Twenty-five tons of the general run of ore that is milled nets 3 or 4 tons of concentrates. The milled ore is not so high in dioxide as the lump ore, but it is all chemical ore. The ore that has been marketed averaged about 80 per cent manganese dioxide, less than 1 per cent iron, and about 5 per cent silica. Two analyses of the mineral pyrolusite as published by Watson and Wherry¹ are given on page 47. Analyses of ore from this mine, as published by Mr. Weeks in 1886, are as follows:

Analyses of ore from Powells Fort mine.

[J. Blodgett Britton, analyst.]

	1	2
Manganese oxide	94.30	94.75
Insoluble (SiO ₂)	1.78	3.78
Alumina (Al ₂ O ₃)	1.10	.25
Baryta (BaO)	1.30	.42
Iron oxides, lime, manganese[?]	.50	.43
Moisture	.28	.37
Undetermined	.74	
	100.00	100.00

*Mining and preparation of ore.*²—The Stockwood Realty Corporation developed the mine during 1916 to 1919 by two inclined shafts and two vertical shafts, all connecting with a definite underground system of cross-cuts and drifts. (See Pl. XXIII.) Since the development of the underground system the inclined shafts have been used as chutes to carry timbers to the underground levels, and the main vertical shafts have been used for hoisting ways for the ore. Considerable trouble was at first experienced by the soft flowing wet sands in the ore formation but by locating the shafts far enough from the outcrop of the ore zone to gain sufficient depth

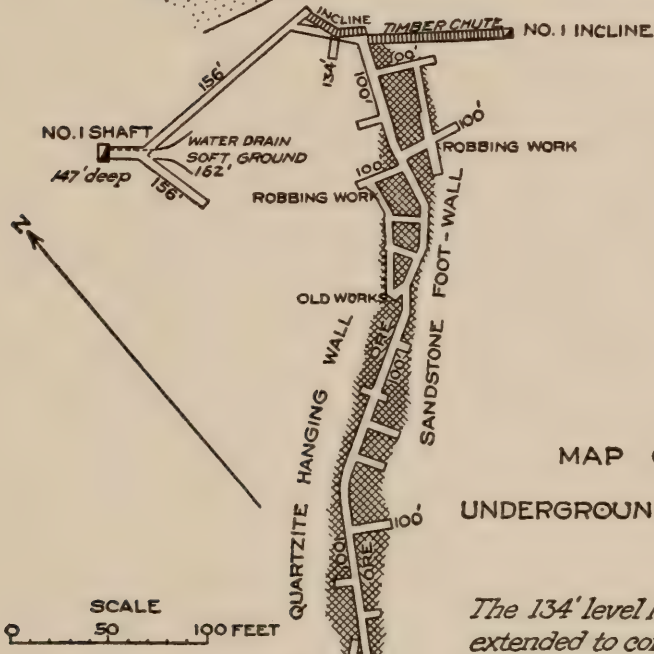
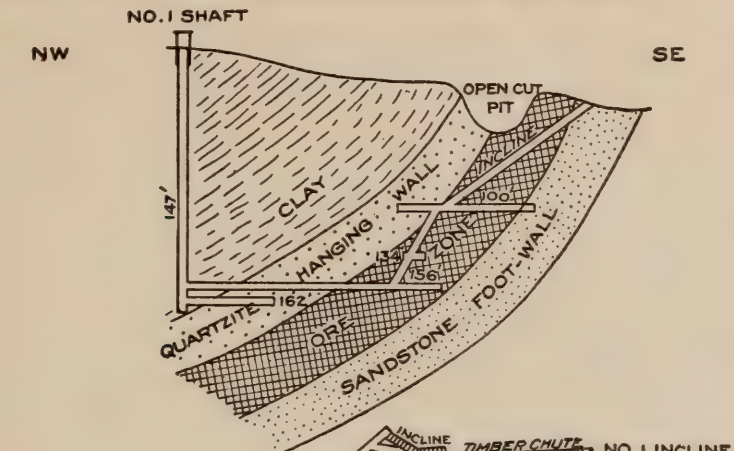
¹ Idem.

² Contributed by J. Carson Adkerson.

MAP AND PROJECTED CROSS SECTIONS OF THE UNDERGROUND WORKINGS OF THE POWELLS FORT MINE IN 1918

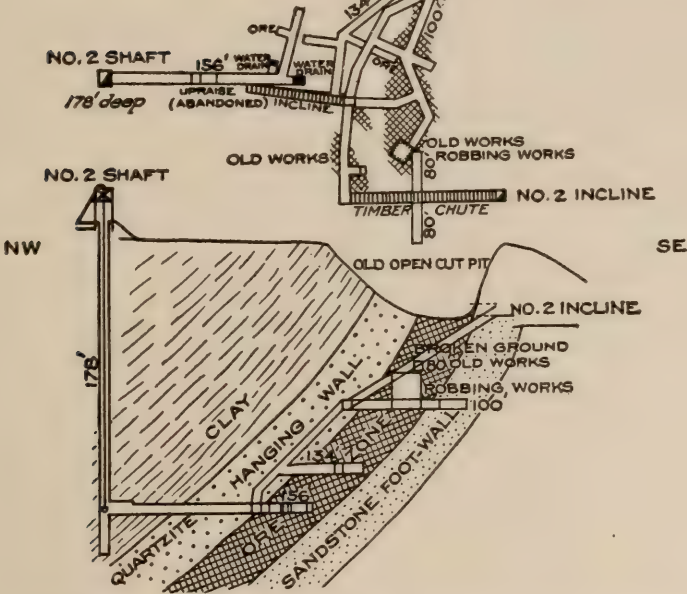
By J. Carson Adkerson

PROJECTED CROSS SECTION THROUGH NO. 1 SHAFT



MAP OF UNDERGROUND WORKINGS

The 134' level has since been extended to connect workings from shafts 1 and 2.



PROJECTED CROSS SECTION THROUGH NO. 2 SHAFT

before puncturing the quartzite hanging wall (see sections on Pl. XXIII) and by a special system of working on the lower level this trouble was completely overcome.

The deposit was developed and operated for a distance of approximately 600 feet along the strike of the ore-bearing formation and to a depth of approximately 150 feet. The underground system consisted of three main levels on which cars were operated, with several sub-levels between. The ore, after being broken from place, was handled by gravity through chutes to cars on the main level next below and conveyed to the shafts where the cars were hoisted out and then continued by gravity to the mill.

The mill was modern and was completely equipped with crushers, washers, picking belt, rolls, jigs, and tables, so that the finest particles of ore were saved. The ore was handled in the mill largely by gravity and automatic machinery. The ore from the picking belt ran from 80 to 87 per cent manganese dioxide (MnO_2), less than one per cent iron, and low in silica and other impurities. The jigs yielded products ranging from 76 to 84 per cent manganese dioxide, .50 to 1.50 per cent iron, and 4 to 6 per cent silica. The tables with 12 and 24 mesh screens yielded a product averaging 80 per cent manganese dioxide, 1.50 per cent iron, and 5 per cent silica. The ore was shipped in barrels and bags to plants of the National Carbon Company for dry battery manufacture.

PHILADELPHIA AND OREGON MINES.

The old Philadelphia mine is in the first valley southeast of Fort Mountain, $1\frac{1}{2}$ miles northeast of Powells Fort mine and 7 miles northeast of Woodstock. (See fig. 12.) It is $\frac{1}{2}$ mile west of Mud Hole Gap in Green Ridge, here the second ridge of Massanutten Mountain. As described by R. J. Holden¹ the mine is close to the foot of Fort Mountain and the deposit is in the same ore zone and same syncline as the Powells Fort deposit, but is apparently on the northwest limb of the syncline, whereas the Powells Fort mine is on the southeast limb. The stratigraphic relations are hidden by sandstone wash. The old workings consisted of several pits and tunnels, but the main visible opening in 1909 was a circular pit 15 feet deep in which soft blue pyrolusite was seen in pockets. The ore falls to powder on handling, which makes it difficult to mine. Several hundred tons of manganese ore were reported to have been shipped.

¹ U. S. Geol. Survey Bull. 427, p. 68, 1910.

In 1918 the Stockwood Realty Co. leased the Philadelphia mine from the United States Government, the property having been acquired by the Government as a Forest Reserve, and further prospecting was done by two shafts 40 feet deep, 1,500 feet apart, and by 100 feet of drifts from the bottoms of the shafts. Favorable conditions were reported to have been found but no mining was done. The property was not visited by the writers after this prospecting was done.

Indications of manganese ore are reported to occur still farther to the northeast in the same syncline, especially at the old Oregon iron mine, 4 miles northeast of the Powells Fort mine, where R. J. Holden¹ reported abundant blue pyrolusite and manganiferous ore in the dump of the old mine.

CAMERON PROSPECT.

The Cameron prospect, which is on the property formerly owned by Donald Cameron and later sold to W. E. Ferguson, of Baltimore, is beside the wagon road 2 miles southwest of Powells Fort mine and 3½ miles east of Woodstock, near the gap in the second ridge of Massanutten Mountain. (See Pl. II, A.) Prospecting for manganese ore was done in 1916 by the Stockwood Realty Corporation, but no ore was shipped as it was not found in commercial quantity. Prospecting by open cuts had been previously done by Mr. Cameron.

The openings, which are pits and shafts, were made in and near the bottom of a northeastward-trending valley, 1,280 feet above sea level. One of the shafts that was visited is 25 feet deep and is said to have passed through quartzitic conglomerate dipping 45° NW. and penetrated an iron-ore-bearing zone in sandstone 6 to 8 feet thick. A drift, 20 feet long, was run northwest from the shaft, and another to the southeast to the barren sandstone walls on either side. The ore observed on the dump of the shaft was a manganiferous iron ore that had apparently replaced sandstone. The ore zone is probably in the basal Oriskany beds and in underlying rocks of Cayuga age.

HIGHLAND AND BATH COUNTIES.

ACHENBACH TRACT.

In Bath and Highland counties a tract of 29,000 acres, formerly owned by H. E. Achenbach, has been recently acquired by Col. Paschal, of Richmond, and a number of other Virginia men, according to the statement

¹ U. S. Geol. Survey Bull. 427, p. 68, 1910.

of T. M. Gathright, of Covington, one of the interested parties. The property is a wild mountainous country about 3 miles in width, embracing chiefly Back Creek Mountain which lies between Back Creek on the west and Jackson River on the east and extending 26 miles northeast from the junction of these two streams. A report on the property by M. A. Nobles states that the tract contains deposits of manganese ore which range from 28.5 to 60 per cent manganese. Mr. Gathright reported large masses of good-grade manganese ore on the east side of Back Creek Mountain 8 or 10 miles north of Warm Springs. As no prospecting had been done and as the property was too inaccessible from railroad transportation to be developed at present, it was not visited by the writers.

BATH COUNTY.

STEPHENSON PROSPECT.

The Stephenson prospect is on the property of Boyd Stephenson, of Monterey, 4½ miles north-northeast of Warm Springs. (See fig. 13.) Work at this place has been done recently by J. Ed. Gillett, who mined and shipped 20 tons of manganese ore prior to the writers' visit (Sept. 7, 1918). The marketed ore was hand-picked, placed in bags, and then hauled 10 miles by wagon to Hot Springs, the shipping point.

A shaft, 25 feet deep, was sunk by the road side, near the bottom of the small south-trending valley tributary to Muddy Run, at an elevation of 2,610 feet above sea level. A drift 50 feet long followed a manganese ore zone, averaging about 2 feet thick, along the strike southwestward. The ore zone consists of clay, calcite, psilomelane, and manganite, and seemed to pass downward at a 25-foot depth into barren coarsely crystalline calcite, and follows the bedding of finely laminated limestone of Cayuga age which is exposed at places at the surface. The limestone dips 60° NW., and varies in color from light to dark gray, and some layers are pink. Another drift, 55 feet long, was driven northwestward from the valley bottom below the road, but calcite was the only mineral found in it. A nearby drillhole is reported to have passed through manganese ore.

A carload of ore was reported by Stuart Marshall, of Washington, to have been mined and shipped in March, 1919, by C. G. Chevalier, of Baltimore.

GILLETT PROSPECT.

The Gillett prospect is on a bench-like terrace on the northwest slope of Jack Mountain, at an elevation of 2,635 feet above sea level, half-a-mile east of Rocky Branch and 7 miles north-northeast of Warm Springs. J.

Ed. Gillett, the owner of the property, made a few small pits as much as 15 feet deep in 1916. The yellow clay penetrated by the pits was found to contain a meagre quantity of manganese oxides (some psilomelane and a

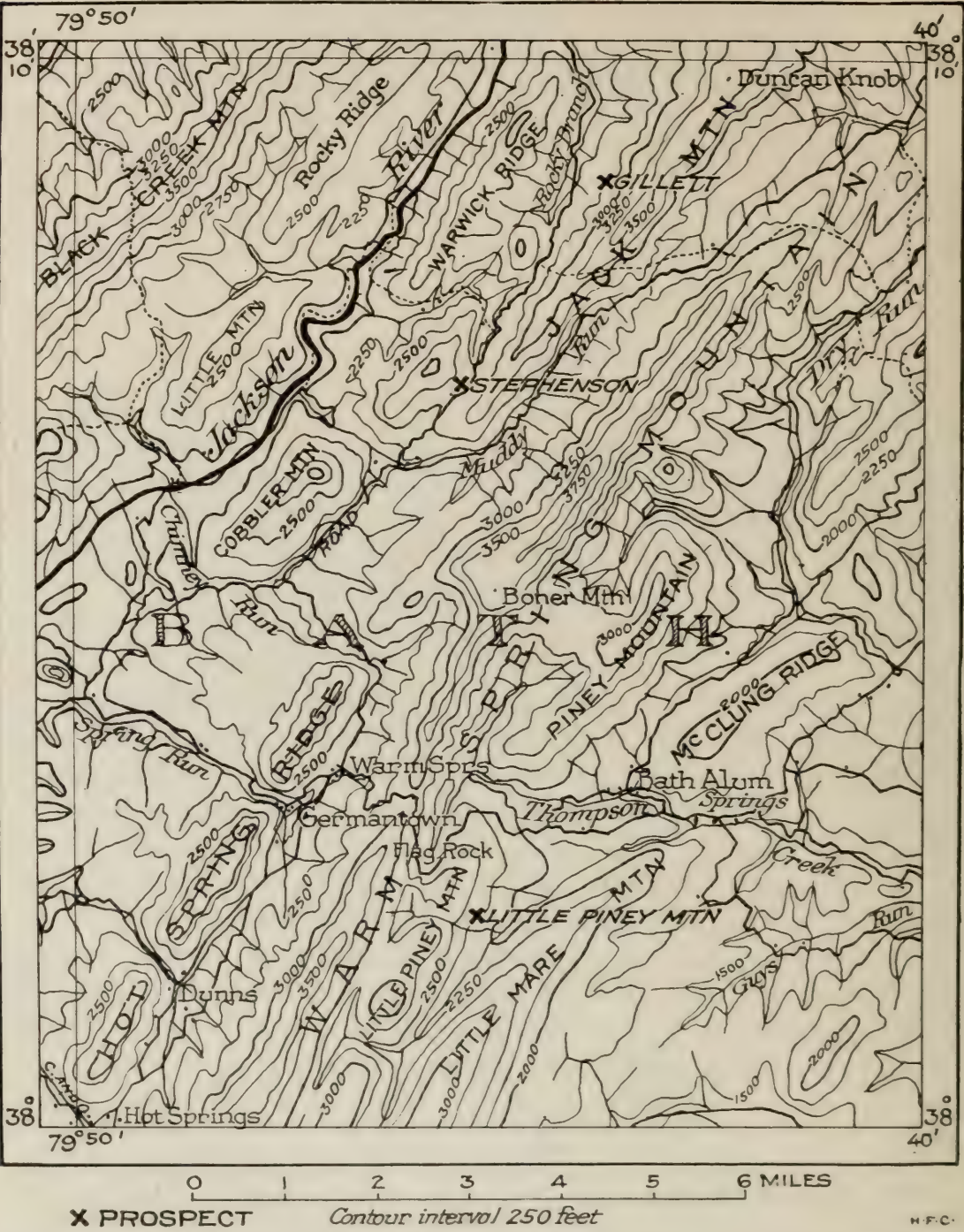


Fig. 13.—Map of a part of Bath County, showing the location of the Gillett, Stephenson, and Little Piney Mountain prospects.

crystalline mineral), in pieces the size of a person's fist or smaller. The discovery of a 25-pound fragment of manganese ore on the slope below the pits led to the prospecting. The clay is apparently residual from limestone of Cayuga age, of which there are exposures in a ravine east of the pits. A heavy quartzite in the upper part of the Clinton formation is exposed in the ravine southeast of the limestone and has a dip of 75° NW., which is believed to be the general dip of the rocks. Similar showings of manganese ore are said to be found to the northeast along the belt of limestone of Cayuga age.

LITTLE PINEY MOUNTAIN PROSPECT.¹

The Little Piney Mountain prospect is 2 miles southeast of Warm Springs and 5 miles northeast of Hot Springs, the nearest station on the Hot Springs Branch of the Chesapeake & Ohio Railroad. It is on Little Piney Mountain, a short northeastward-trending ridge just east of Warm Spring Mountain. It occurs on the top of a very short spur on the southeast slope of the mountain at an elevation of 2,300 feet above sea level or about 400 feet above Gordonsville Branch, the nearest stream.

The prospect is in a tract of 102,000 acres known as the Douthat Survey, which is owned by Senator Peter McLaron, of Bath, Ontario, Canada. The tract extends from Covington in Alleghany County north-eastward to Burnsville, in Bath County, a distance of 30 miles. Hot Springs is just west of its northwest boundary.

The first work at this locality was done soon after 1888, which was the date of the discovery of manganese ore on the property by A. F. Withrow, of Millboro, Va. Two cuts and a pit as much as 6 feet deep, which were made at that time, yielded a few hundred pounds of ore which was observed on the dump at the time of visit.

The manganese deposit occurs in crushed and brecciated sandstone and chert apparently of Cayuga and Helderberg age. It is covered by 1 or 2 feet of yellowish clay, probably residual from weathered limestone. The sandstone and the chert dip 30° SE., on the northwest limb of a shallow syncline $1\frac{1}{2}$ miles in width. They are traversed by a zone of close jointing or sheeting which dips 70° NW. into the mountain, and the ore occurs chiefly as breccia-filling in the fractured rock of this zone and as replacement of the walls of fractures, joints, and bedding planes. The ore is almost wholly psilomelane and is hard, closely laminated, slightly cellular, and in general is banded or has a vein-like structure.

¹ Description by F. C. Schrader.

The deposit trends northeast-southwest and is opened at places through a distance of about 100 feet, mainly by two cuts each 25 feet long and by a pit known as the Rowe shaft. These workings are approximately in alignment and were excavated in yellowish clay and in the underlying crushed and blocky sandstone and chert. The south cut, which is 4 feet deep, yielded about 300 pounds of crude ore, half of which is psilomelane and the other half sandstone or chert. The pit, which is about 5 feet deep, shows near the surface a very small amount of ore, most of which occurs in veins parallel with the bedding in the sandstone. The lumps of ore observed on the dumps indicate that some of the individual veins are as much as 5 or 6 inches thick. Ore from this locality was reported by Mr. Withrow to have given the accompanying analysis. Silica, which is present in most of the ore that was observed by the writer, was obviously not determined in this analysis.

Analysis of manganese ore from the Little Piney Mountain prospect.

[J. B. MacIntosh, analyst.]

Manganese (Mn)	39.78
Iron (Fe)	.07
Cobalt, including a very little nickel.....	2.96
Phosphorus (P)	None
Copper (Cu)	Trace

ALLEGHANY COUNTY.

FALLING SPRING IRON PROSPECT.

The Falling Spring prospect is 5½ miles northeast of Covington, just south of Falling Spring. The opening is on the northwest slope of a long spur of Warm Spring Mountain, about 100 feet above the Warm Spring road. It was recently opened for iron ore by T. M. Gathright, of Covington, and showed an ore bed 6 to 10 feet thick standing nearly vertical between a footwall on the west of knotty chert with clay partings, probably of Helderberg age, and a hanging wall on the east of Oriskany sandstone. The sandstone has been partly replaced by ore, giving rise to a siliceous iron ore body. In the south wall of the opening the ore pinches out and the sandstone rests against chert. No manganese ore was seen.

COVINGTON PROSPECT.¹

The Covington prospect is 4 miles north of Covington and 2 miles by wagon road southeast of Harrington on the Hot Springs Branch of the

¹ Description by F. C. Schrader.

Chesapeake & Ohio Railroad. (See fig. 14.) It is in a small gulch on the lower northwest slope of the southern end of Warm Spring Mountain at an elevation of 1,500 feet above sea level or about 150 feet above Jackson River, and just below the Covington-Hot Springs highway. The flow of the stream in the gulch is apparently adequate to supply water for mining and milling purposes throughout the year. The large tract in which the prospect is located is known as the Douthat Survey and is owned by Senator Peter McLaren, of Bath, Ontario, Canada. The workings consist of a cut and short tunnel which had caved before the time of visit (Nov. 26, 1918.)

The deposit of manganese ore occurs mainly in a steep 12-foot bank on the north side of the gulch about 6 feet above the stream. It consists of

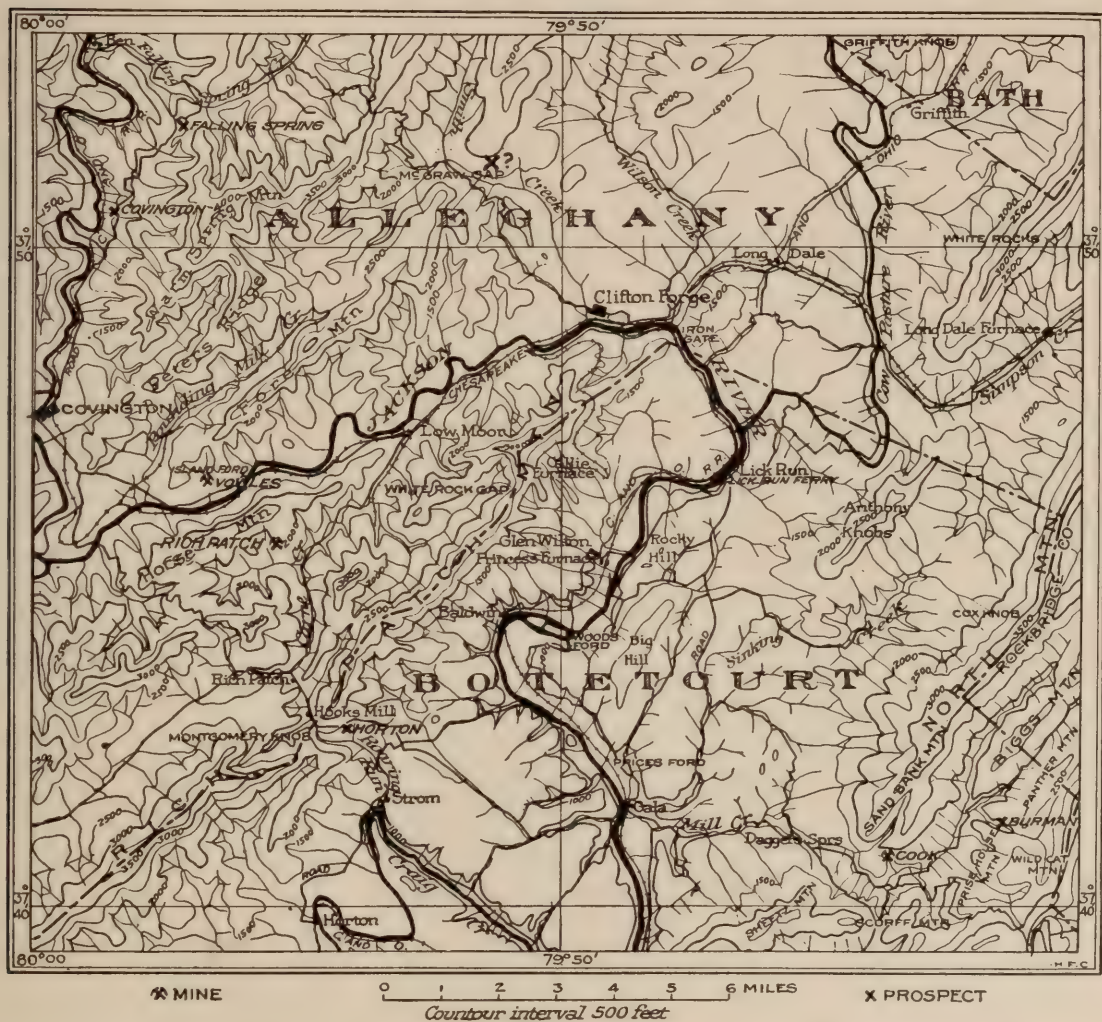


Fig. 14.—Map of parts of Alleghany and Botetourt counties, showing the location of the manganese mines and prospects.

lumps, nodules, and small particles of ore sporadically distributed in yellowish and reddish brown residual clay which contains some partly disintegrated sandstone or sandy shale. It is next to a footwall of relatively hard coarse sandstone. It seems to have a width of about 20 feet, although manganese stains and a few bits of ore were found in the sandy shale of the bank for a distance of 100 feet up stream from the opening.

The ore minerals are psilomelane and a very little wad. Associated minerals are silica, limonite, and hematite. Most of the ore is in lumps, which are as much as 5 inches in diameter and are generally rough and irregular in shape, but much of it is in nodules with typical botryoidal surfaces, coated red with hematite. The nodules seem to be relatively pure but the irregular lumps contain considerable silica, some of which is present in angular cherty pieces but the most of it occurs as rounded grains and fine particles of glassy quartz disseminated throughout the psilomelane. The quantity of ore is apparently too small for the deposit to be of commercial importance. Only about 100 pounds of ore had been removed from the workings and placed on the dump.

The deposit occurs in Oriskany sandstone near its contact with Romney shale. The ore-bearing beds dip about 70° NW.

McGRAW GAP.

Float manganese ore is reported to be conspicuous on the surface at and near McGraw Gap, 8 miles northeast of Covington. The area on which the manganese ore occurs is in the Douthat Survey, which is owned by Senator Peter McLaren, of Bath, Ontario, Canada. It was not visited by the writers.

RICH PATCH IRON MINE.

The Rich Patch iron mine is in Carne Creek valley, 6 miles southeast of Covington, between Rich Patch Mountain on the southeast and Horse Mountain on the northwest. Only a few of the openings were examined by the writers for the purpose of studying the relations and occurrence of the ore. The iron ore was observed to lie between fossiliferous chert beds of Helderberg age on the west, and the granular sandstone of supposed Oriskany age on the east, which is in turn overlain in the valley by Devonian black shale. At the open cut No. 5, near the south end of the development, the ore bed is about 30 feet thick and is composed of almost solid, laminated, and irregularly jointed ore. The hanging wall on the

east side is rust-stained sandstone, shaly toward the top. The foot wall is irregular bedded massive chert, 35 feet thick, dipping 60° to 70° southeast and resting on much disturbed clay. The upper surface of the chert is very irregular and pitted and in the depressions is coated with a thin film of red iron oxide. There are also small flattened concretions of psilomelane on the chert surface and in crevices, but there is no appreciable amount of manganese ore present in the iron ore.

The open cut No. 1 at the northeast end of the property is 100 feet deep. The ore has been recently mined from a tunnel 60 feet below the bottom of the open cut, and a shaft follows the ore to a depth of 233 feet below the surface. The ore contains sand grains and brecciated sandstone near the hanging wall and chert fragments near the footwall.

VOWLES MINE.

The Vowles mine is at the south end of Fore Mountain, 4 miles southeast of Covington. (See fig. 14.) It was worked some time before 1890 and was next worked by D. A. Vowles, of Huntington, W. Va., beginning in 1917. Fore Mountain is an anticline which plunges southwest toward Jackson River. On the lower southeast slope of the mountain are thin sandstones underlain by limestone. These sandstones dip to the southeast into the syncline along Jackson River in which Devonian shales are inclosed. The ore is in clay below a roof of rusty fossiliferous sandstone of Oriskany (probably Ridgely) age. The clay is apparently residual from calcareous beds, and in places rests on massive crystalline limestone containing *Spirifers* and other brachiopods of Oriskany (Ridgely) age. In the road cut southwest of the mine the beds immediately below the heavy sandstone are seen to be shaly limestone interbedded with thin sandstones.

The mine comprises 3 tunnels and drifts on one side of the ravine and another longer tunnel with drifts on the other side. (See fig. 15.) The ore bed is 18 inches to 6 feet thick. Most of the ore is loose textured iron ore, with but little psilomelane, and is therefore a manganiferous iron ore. About 400 tons were reported to have been mined and shipped from old workings sometime before 1890. In 1917 Mr. Vowles shipped about 13 car loads of manganiferous iron ore and in the spring of 1918 about 8 car loads. The ore mined in 1918 averaged 36 per cent of iron, 11 per cent of manganese, and 10 per cent of silica and was shipped to Iron Gate and Lowmoor furnaces.

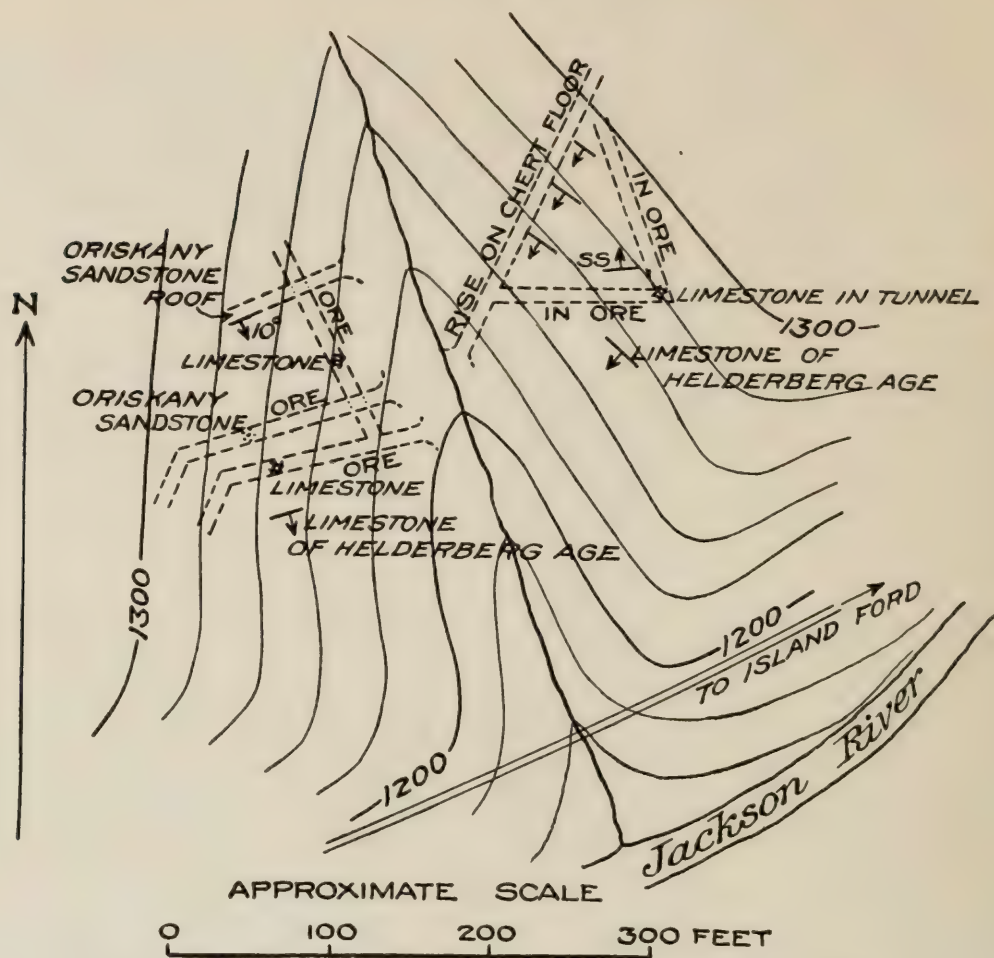


Fig. 15.—Sketch map of the Vowles mine, Alleghany County.

BOTETOURT COUNTY.

HORTON PROSPECT.¹

The Horton prospect, also known as the Roaring Run prospect, is on the southeast slope of Rich Patch Mountain, just north of Roaring Run, 4 miles north of Horton on the Craig Valley Branch of the Chesapeake & Ohio Railroad. (See fig. 14.) It is near the center of a tract of about 10,000 acres known as the Roaring Run (or Horton) property, which was formerly owned by H. L. Horton, of New York, but is now owned by E. F. Hutton, of New York.

It is on the top of a spur which is about one-third of a mile long and has an elevation of about 1,600 feet above sea level or 300 feet above Roaring Run at the base of the mountain. The top of this spur is one of

¹ Description by F. C. Schrader.

many similar remnants of a former extensive peneplain that stood at this level and that was formed by processes of erosion which played an important part in liberating from the eroded rocks the disseminated manganese ore minerals and in concentrating them into workable deposits.

The deposit as revealed by the workings occurs in shaly sandstone, probably of Cayuga age, which is overlain nearby by limestone, probably of Helderberg age. These formations are steeply tilted to the southeast so that they occur in narrow belts whose width corresponds approximately to the thickness of the formations.

The workings, which are a shaft and a cut about 220 feet apart, are approximately in alignment and parallel to the northeast strike of the rocks, seemingly on the same zone of mineralization and possibly on one and the same deposit. At both openings the ore consists of nodules, lumps, and fine pieces of hard psilomelane, which were apparently embedded in yellowish and reddish brown clay. The material on the dump at the shaft, which appeared to be about 20 feet deep, indicates that it was sunk in clay and that only a small amount of ore was found, the largest piece seen by the writer being 3 inches in diameter. The cut, which is 30 feet long by 4 feet deep, is southwest of and slightly lower than the shaft, and runs northeastward into the ridge. It was dug in clay and about one-fourth of a ton of ore taken from it was still on the dump. Some ore may have been mined many years ago for use in the Roaring Run furnace, which was nearby.

The ore consists of nodules and lumps having mammillary, stalactitic, botryoidal, and platy forms, which weigh as much as 100 pounds. Certain laminated and tabular forms suggest that some of the ore replaced rocks that were very thin bedded. The ore as a whole is relatively pure and free from iron and silica. Some of the nodules, however, are in part coated from red hematite.

COOK MINE.¹

The Cook mine, formerly called the Ruhl mine, is 2 miles east of Daggers Springs and 5 miles east of Gala on the Chesapeake & Ohio Railroad. (See fig. 14.) It is on the southeast slope of the south end of North Mountain at an elevation of 1,700 feet above sea level or 200 feet above an adjacent small tributary on Mill Creek.

The mine is on a large tract owned by the D. S. Cook & Son Mining Co., of Wrightsville, Pa. It was worked in 1911 and is reported to have

¹ Description by F. C. Schrader.

produced at that time 120 tons of marketed ore that averaged 54 per cent manganese. More recently some additional work was done on the property, at which time 3 tons of ore, averaging 35 per cent manganese, were concentrated in a hand washer at the foot of the slope and shipped. This work was apparently done by W. J. Overbeck, who was reported to have leased the property.

The principal workings are a cut 40 feet long by 20 feet wide and 18 feet deep at the face, and a tunnel which extended 75 feet northeastward from the face of the cut and is said to have shown ore all the way but was caved at the time of visit. The workings are in beds of sandstone and clay, probably of Cayuga or of Helderberg age, which dip 55° SE. These beds contain nodules or lenses of iron-stained chert in which fossil bryozoa are abundant in places. They are concealed at the surface by about 3 feet of yellowish-brown clayey soil.

The deposit as revealed in the cut consists mainly of a tabular body of manganese ore about 4 feet thick inclosed in yellowish-brown residual clay, which is largely parallel with the bedding of the clay and the associated sandstone. The ore occurs mostly as tabular shoots, lumps, nodules, and small particles down to the size of shot ore most irregularly distributed through the clay. Some shoots are as much as 18 inches thick. The principal manganese mineral is psilomelane, which is accompanied by considerable manganite and a little wad and pyrolusite. The manganite occurs mostly in concentric encircling bands of radiating fibers or needle-like crystals and in places lines cavities. The associated minerals are hematite, limonite, and quartz. About 4 feet from the hanging wall there occurs a more or less continuous seam of relatively pure hematite, which varies from 1 inch to 18 inches in thickness. The manganese ore occurs in small quantity and contains a large percentage of silica. The silica, which is mostly mixed with clay, occurs in irregular, rounded and subangular, whitish bodies ranging up to one-third of an inch in diameter disseminated through the ore. A few small rounded particles of glassy quartz are also present.

Some old workings, consisting chiefly of a caved-in tunnel, are 70 feet southeast of the above-described openings and lower down the slope. The tunnel runs northwestward and the material on the dump indicates that it followed a zone of mineralized fault breccia of quartzite and chert, which is firmly cemented and in part replaced by manganese ore minerals, chiefly psilomelane. The ore probably contains too much silica in the form of

rock fragments and fine grains of glassy quartz to be worked under present conditions. It is possible, however, that at the intersection of the breccia zone with the main lode the deposit may be larger or richer.

In the vicinity of the Cook mine manganese oxides occur as small fragments on the surface, as a stain in the soil and clay, and as a stain in some of the sandstone that crops out on the surface. Such indications of manganese ore are said to extend several miles both to the northeast and southwest of the mine. One prospect southwest of the mine is said to have yielded a small quantity of ore.

BURMAN PROSPECT.¹

The Burman prospect, which is on timbered land belonging to J. B. Burman, of Daggers Springs, is $3\frac{1}{2}$ miles east of Daggers Springs, and 7 miles east of Gala, on the Chesapeake & Ohio Railroad. It is 2 miles east-northeast of the Cook mine. (See fig. 14.) The prospect is on the southwest slope of Panther Mountain, a parallel foothill of Camp Mountain on the southeast, at an altitude of 1,900 feet above sea level and 20 feet above and just north of Sloan Creek, a tributary of Mill Creek. The prospect is a northeastward-trending cut 20 feet long, which was made about 1910 and from which about one ton of manganese ore, which is still on the dump, was removed.

The deposit occurs chiefly in yellowish-brown clay residual from limestone, probably of Helderberg age. The clay is as much as 25 feet thick in places, and generally conceals the limestone. There are exposures of the limestone within 30 feet of the cut and in the bed and banks of the creek. The limestone is reddish, impure, and thin bedded or laminated and dips 60° SE. The ore occurs chiefly as nodules and to a small extent as laminated slablike forms, and seems to have been deposited by infiltration in, and by replacement of, the clay and limestone. The nodules are mostly round, ranging from 3 to 8 inches in diameter. They have an ill-defined irregular concentric shell-like structure. Manganite is apparently the only manganese mineral present. Most of it is fine grained or cryptocrystalline, in which are a few thin concentric layers of radiating fibers. Manganite of later origin occurs as bright crystals on the surface of some nodules.

The ore is remarkably free from iron, silica, and other impurities and is therefore of good quality. Further prospecting may be warranted to determine the size of the ore body.

¹ Description by F. C. Schrader.

PURGATORY MOUNTAIN PROSPECTS.

Manganese ore is reported to occur in the Purgatory Mountains 6 to 8 miles north of Buchanan. The openings were made by C. M. Stranahan, of Covington, who stated that they lie on the lower west slope of Purgatory Mountain below the outcrop of the Clinton iron ore and therefore probably in the Oriskany horizon, the structure being monoclinal with dips to the west. One prospect is near the head of Penn Branch, below Cartwell Gap in Purgatory Mountain, and the other is 3 miles to the north on the slope of Round Mountain. The ore is reported to carry 37 per cent manganese and 8 per cent iron. The property was not visited by the writers.

CRAIG COUNTY.**FENWICK IRON MINE.**

The Fenwick iron mine, operated by the Lowmoor Iron Co., is at the head of Mill Creek, 8 miles northeast of Newcastle. Only one working was examined by the writers to determine the relation of the ore to the rock formations. A shaft 145 feet deep, with several drifts, was visited. The shaft is in the Devonian black shale and the drifts run northwest through about 50 feet of underlying sandstone and clay, presumably Oriskany sandstone, to an iron ore bed 5 to 20 feet thick. The ore has been stoped nearly up to the bottom of the deep open cut at the surface. The ore rests on buff fossiliferous chert of Becraft (upper Helderberg) age, which is decomposed in places to a soft white siliceous mass with some associated pure white plastic clay. No manganese ore was observed.

PETERS HILL PROSPECT.

Ore was reported by William Echols, of Newcastle, to occur in Peters Hill, 2½ miles west of Newcastle, near the road up Johns Creek. It was said to be largely iron ore and the place was not visited by the writers. It is apparently in sandstones and shales of Cayuga age, which are exposed along the road.

RED BRUSH PROSPECT.

The Red Brush prospect is on F. B. Wagoner's farm on Big Branch of Johns Creek, 5 miles in an air line northwest of Newcastle but 9 miles by wagon road from that place. (See fig. 16.) This farm is also known as the Robinson tract. Work was being done by W. K. Bell, of Newcastle,

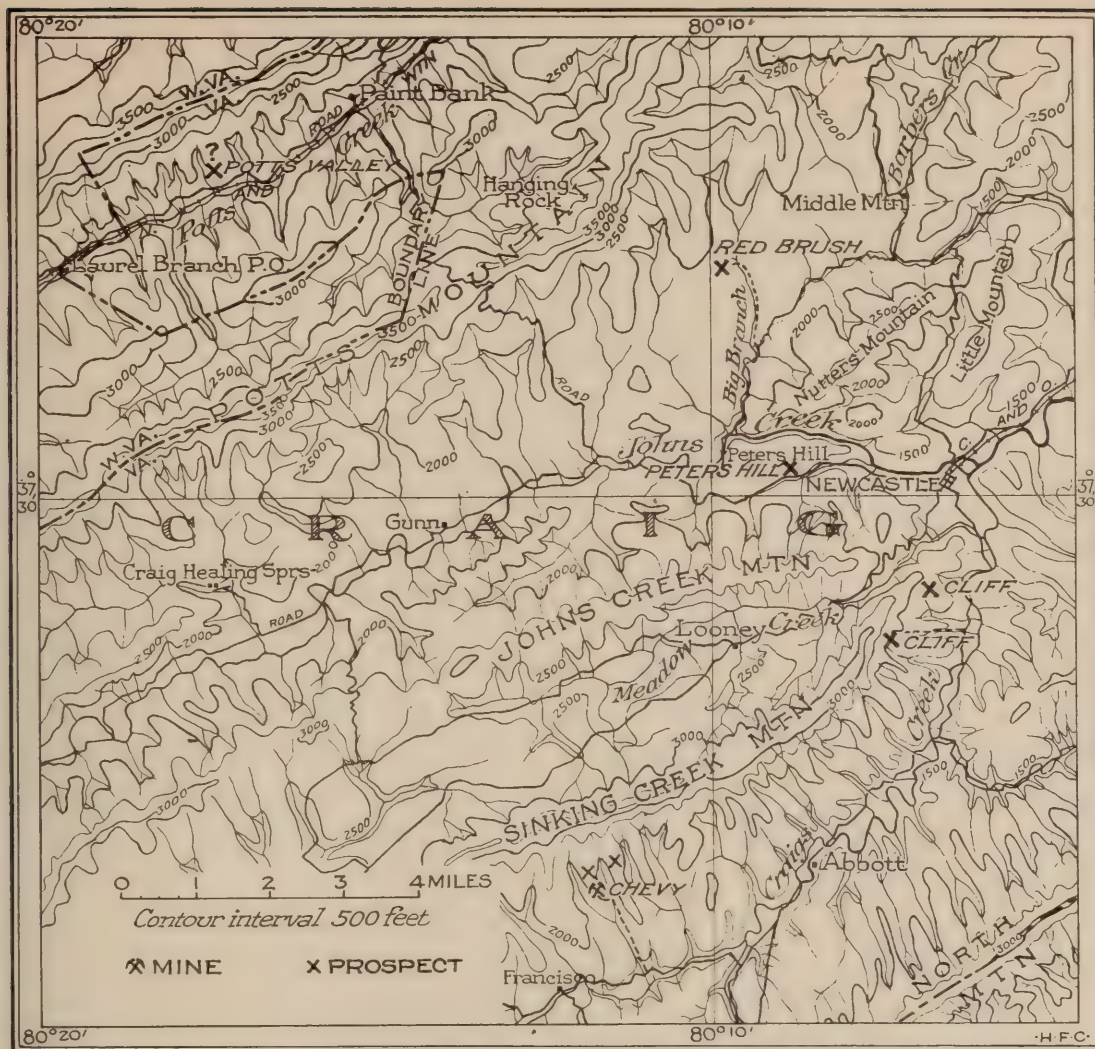


Fig. 16.—Map of a part of Craig County, showing the location of the manganese mines and prospects near Newcastle.

at the time of visit (Sept. 4, 1918), and 20 tons of hand-picked manganese ore had been hauled by wagon to Newcastle, whence it was to be shipped.

The principal openings are a small cut, a few feet deep, and a shaft, 15 feet deep, on a low hill 1,900 feet above sea level, the top of which is part of the valley-floor peneplain. The cut is just north of a small stream and much of it is below the bed of the stream so that there has been some difficulty in keeping water out of the cut. It reveals yellow sandstone and an underlying bed of laminated variegated clay, probably of Cayuga age, both of which dip about 20° SSE. Masses of psilomelane, which weigh as much as several pounds and are nodular and slabby in outline and platy

in structure, make up a large part of a bed of clay $4\frac{1}{2}$ to 5 feet thick just below the sandstone. That the psilomelane has replaced the clay is shown by the preservation of the laminated structure of the clay not only on the surface of the masses of psilomelane but also within them. (See Plates XI and XII.) The ore is reported to run 32 to 42 per cent manganese (average 38), 15 to 20 per cent silica, and 2 to 5 per cent iron.

Another opening consists of a tunnel 20 feet long, which has been driven S. 65° E. into clay at the base of a hill 100 yards north of the cut. Only a small quantity of manganese ore had been obtained from the clay at the time of visit.

POTTS VALLEY PROSPECTS.

Manganese ore was reported to have been mined by O. B. Adkins, of Radford, and Mr. Persinger, of Salem, in Potts Valley 2 miles southwest of Paint Bank. A car load of ore was reported shipped in the spring of 1918. The property was not visited by the writers, but manganese oxide was observed filling crevices along joints and on bedding planes of Oriskany sandstone in the cuts of Paint Bank Branch of the Norfolk & Western Railway at the head of Potts Creek in West Virginia, a few miles to the southwest of the prospects. Potts Valley is a syncline inclosing Oriskany sandstone and the manganese is probably associated with that formation at the prospects.

CLIFF PROSPECT.

The Cliff prospect, also called the Overbeck prospect, is on the property held in trust by John L. Dickinson, of Charleston, W. Va., on the southeast slope of Sinking Creek Mountain 3 miles south-southwest of Newcastle and about 1 mile west of Craigs Creek. (See fig. 16.) Work has been done here recently by W. J. Overbeck, of Cincinnati, O., and one car load of ore had been reported shipped at the time of visit (Sept. 3, 1918.)

The workings consist of two tunnels near the top of a bench at an elevation of 2,200 feet above sea level or 830 feet above Craigs Creek. One of these, 12 feet long, passes through a gray sandstone which strikes N. 10° W., and dips 35° E., and penetrates brown clay at the face. No manganese minerals were observed in either the sandstone or the clay. Another tunnel, which had caved but was said to be 30 feet long, enters the south face of the spur a short distance to the southwest of the first tunnel, and was driven in brown sandy clay and thin sandstone which underlie the upper sandstone. These rocks are apparently of Cayuga age. Manganese and

iron oxides occur in considerable quantity in a bed of sandy shale 4 or 5 feet thick which they have replaced, and they are so intimately intermixed that it would be impossible to separate them. (See Pl. XVI.) The manganese oxides are chiefly psilomelane with some manganite in tubular or nodular form. Some of the ore was hand-picked and carried down the mountain by gravity in an inclined ore shoot 400 feet long, into a bin. The bin at the time of visit had about 10 tons of ore in it containing about 25 per cent manganese and an equal amount of iron. The ore is said to run 37 to 43 per cent manganese and iron, or an average of 13.8 per cent manganese. A road $1\frac{1}{2}$ miles long had been constructed down the mountain to the public road.

Another opening had been made on a spur 1 mile to the northeast in similar sandstone and shale, from which a car load of ore was also reported to have been obtained. This pit was not visited by the writers.

CHEVY MINE.

The Chevy mine consists of a considerable number of scattered openings on the southeast slope of Sinking Creek Mountain, 12 miles by wagon road southwest of Newcastle, and is on property which is owned by the heirs of C. C. Lewis, Sr. (See fig. 16.) Work at this locality was begun in the fall of 1916 by C. G. Chevalier, of Baltimore, and was in progress at the time of visit (Sept. 3, 1918). Several hundred tons of manganese ore was mined and all of it was shipped to the Carnegie Steel Co. The marketed ore was separated by hand from the associated clay and sandstone and was hauled in wagons and trucks to Newcastle, where it was shipped.

The principal opening is a cut about 60 feet long, 40 feet wide, and 5 to 10 feet deep, which is on the top of a sloping spur of the mountain 1,930 feet above sea level or 450 feet above Craigs Creek. (See fig. 17.) The cut has been made in a sandstone 5 to 6 feet thick which dips 10° S. toward Craigs Creek and in sandy yellow clay streaked with purple and white that underlies the sandstone. A shaft in the bottom of the cut is said to show the clay to be about 30 feet thick and to be underlain by a very hard sandstone. A bed of gray to buff sandstone, which outcrops as cavernous ledges in the hollows on either side of the spur, is probably the same sandstone as that found in the shaft, and was encountered in several other pits higher up the mountain. The manganese ore consists mainly of psilomelane and occurs mostly as pockets in the upper part of the sandy clay but some of it occupies fissures, cracks, and joints in the overlying sandstone and has replaced parts of it. Although much of the ore is com-

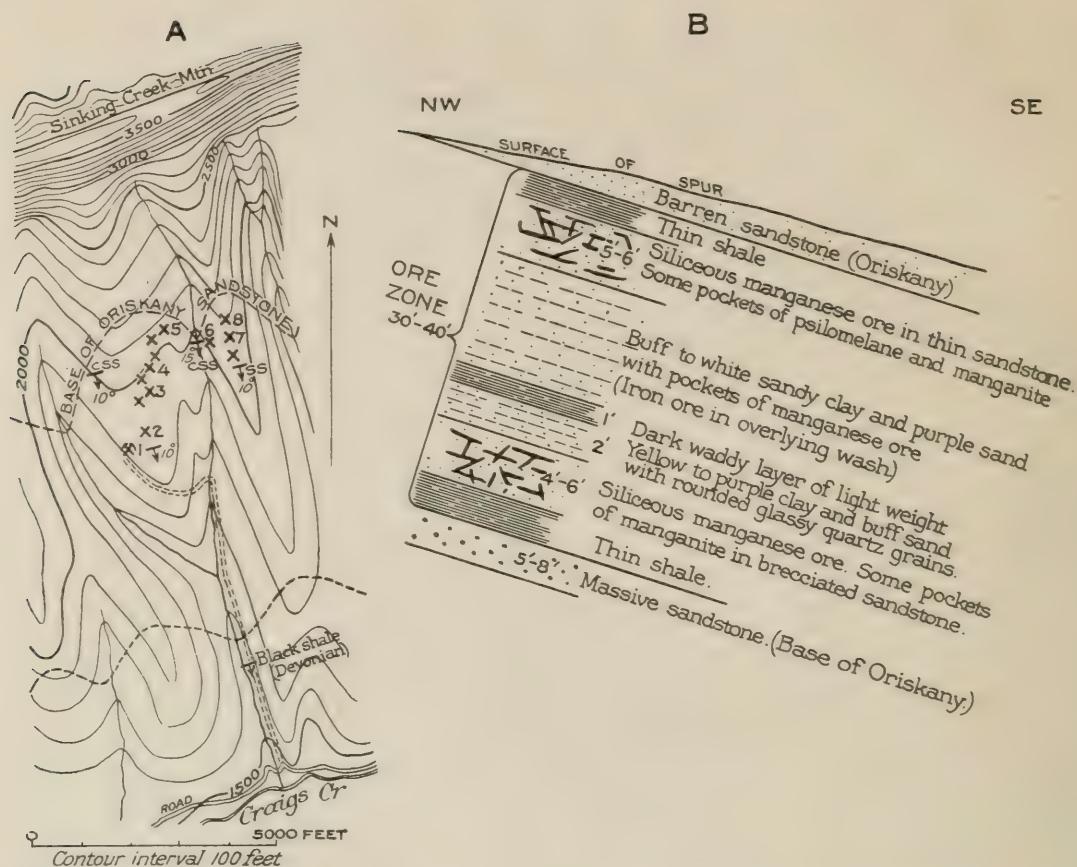


Fig. 17.—Sketch map (A) of the Chevy mine, Craig County, and section (B) at the mine.

pact and free from impurities, some of it contains clay, sandstone fragments, and disseminated grains of quartz.

A shallow cut which occurs at an elevation of 1,980 feet above sea level was made in fractured sandstone that has been replaced in places by manganese oxide. The cut, which is about 100 feet long and of irregular shape, followed the part of the sandstone that had been replaced and is said to have produced 2 carloads of manganese ore. Much of the larger masses of ore is siliceous.

Another small cut, at an elevation of 2,100 feet above sea level, penetrated rocky surficial material to a depth of 8 feet and is said to have produced one carload of manganese ore, chiefly from near the base of the surficial material. Some of this ore observed by the writers contained much sand. Several shallow near-by pits are in clay and sandstone. Some of them revealed brown iron oxide and the others revealed a small quantity of manganese oxide.

A second group of cuts, none of which exceed 10 feet in depth, is on and near the crest of a spur three-fourths of a mile northeast of the first spur. They penetrated beds of ore-bearing clay and sandstone which dip 10° to 15° to the south, that lie between an upper barren sandstone 5 feet thick and a hard coarse sandstone below. The lowermost cut revealed a bed of friable yellow sandstone and yellow clay, as much as 6 feet thick, that had been partly replaced by manganese oxide. Ore that had been obtained from the bed and placed on the dump appeared to contain between 10 and 15 per cent of silica. A near-by cut shows a 5- to 6-foot bed of sandstone that has been partly replaced by manganese oxide. Although most of the manganese oxide in it contains much sand and fragments of sandstone and some of it has a high iron content, this cut furnished the bulk of a car-load of ore which has been shipped from this group of openings. Manganese and iron oxides were revealed in other though smaller cuts in the vicinity, chiefly at the base of the surficial wash. In one of them a small pocket of soft blue high-grade crystalline manganese oxide, probably pyrolusite, was found. This high-grade oxide was placed in sacks and shipped.

The sandstone beds and the clay derived from shaly beds are apparently part of the Oriskany formation.

HOFFMAN MINE.

The Hoffman mine is on the C. L. Hoffman place about $1\frac{1}{2}$ miles southwest of Simmonsville and 1 mile north of Sinking Creek. (See fig. 18.) The mineral right of the property is owned by the Laing Brothers, but the work at time of visit (Sept. 2, 1918) was being done by C. G. Chevalier, of Baltimore, who had mined and placed on the dump about 100 tons of hand-picked lump ore. Preparations were being made to haul this ore by truck to Newcastle, a distance of about 21 miles, for shipment.

The prospect is near the crest of a well-rounded hill about 2,700 feet above sea level. This and other near-by hills having the same elevation apparently mark a former, though now largely eroded, peneplain, herein called the valley-floor peneplain. This part of Sinking Creek Valley is underlain by the Knox dolomite, though the dolomite is concealed by a thick deposit of residual clay in which there is at some places considerable chert.

A shaft 84 feet deep in cherty clay, from which iron ore was mined 30 years ago, is located near the top of the hill, but it had caved before the time of visit and the material on the dumps had become so scattered that the presence or absence of manganese minerals in it could not be determined.



Fig. 18.—Map of parts of Craig and Giles counties, showing the location of the manganese prospects near Simmonsville, Newport, Mountain Lake, Interior, and Pembroke.

Work at the time of visit was being confined to a shallow cut which revealed a bed of red surficial loam as much as 4 feet thick and below this a sticky yellow clay containing chert fragments. Masses of manganese ore have been found in both the clay and loam. The ore in the loam apparently occurs in the ratio of one part of ore to two parts of ore-bearing loam. The quantity of it in the clay is apparently less than that in the loam, but the clay had not been thoroughly prospected. The masses are irregular in shape; range in size from fine particles to boulders weighing 1 ton; are more or less porous and include some clay; and some contain chert frag-

ments. The ore consists of psilomelane, manganite, and wad, which are generally intermixed; some of the manganite occurs as radiating needles in plumose and nodular aggregates. (See Pls. XIII and XV.)

HOFFMAN AND GIVENS PROSPECTS.

The Laing Brothers are said to hold the mining rights on F. H. Hoffman's place, to the northeast across the draw from the Hoffman mine, and on L. P. Hoffman's farm $1\frac{1}{2}$ miles northwest of the mine. These properties have been prospected to a shallow depth by William Echols, of Newcastle, and one ton of ore was said to have been taken out at the time the writers were in the region. They are on hilltops that were part of the valley-floor peneplain and are underlain by Knox dolomite, and the occurrence and character of the ore are probably the same as those of the ore at the Hoffman mine. Good showings of ore are also reported by William Echols on land owned by M. L. Givens on a hill of similar elevation, northeast of F. H. Hoffman's place.

These properties were not visited by the writers but would appear to be favorable ground for prospecting.

MONTGOMERY COUNTY.

GAP MOUNTAIN PROSPECTS.

Manganese ore is reported on the south slope of Gap Mountain in the valleys of Norris Run, Lick Creek, and Poverty Creek east of New River. Prospecting has been done on the farm of Jas. Childress, of Christiansburg. Much of the rest of the mineral land is reported to be owned by Gordon Bros., of Philadelphia. Oriskany sandstone forms the south slope of the mountain and is probably the source of the ore. None of the prospects were visited by the writers.

GILES COUNTY.

CARRIE PROSPECT.

The Carrie prospect, which is on the W. P. Reynolds place, is $2\frac{1}{2}$ miles northeast of the village of Newport and half a mile north of Sinking Creek. (See fig. 18.) The first work at this locality was done by Linkous and Shumate and the work at the time of visit (Aug. 29, 1918) was being done by A. H. Stowe, of Bluefield, W. Va., who had leased the property.

The openings consist of a number of pits and cuts as much as 20 feet deep over an area of 2 or 3 acres on and near the top of small terrace-like

bench at the south base of a mountain. The bench is about 2,600 feet above sea level. Its surface, together with the tops of the near-by hills in the Sinking Creek Valley of about the same elevation, apparently marks a former, though now largely destroyed, peneplain, here called the valley-floor peneplain. The Knox dolomite underlies this valley and also the bench on which the prospect occurs, though the openings penetrate its residual materials—yellow clay and chert—without revealing the dolomite below.

The relations of the rocks in the vicinity of the prospect indicate that the Knox dolomite has been thrust from the southeast upon much younger rocks along a fault which passes in a northeast direction just north of the ore body. The pit that is farthest north penetrates a friable yellow sandstone which is probably in place and which is apparently of Cayuga age. The Clinton and Clinch formations with a steep dip to the south are present higher on the mountain.

The manganese ore is hard and consists mostly of psilomelane but partly of wad and manganite and some of it has botryoidal surfaces. (See Plate XV.) It is confined to the chert-bearing parts of the residual clay of the Knox dolomite and not only does it cement chert fragments together but some of it has partly replaced the fragments. It was being separated from the chert by means of hammers at the time of visit and the plan at that time was to obtain by this means a carload of ore which was to be hauled to Blacksburg, a distance of 9 or 10 miles, for shipment. To produce a fairly large quantity of ore at this locality would require the erection of a mill equipped with machinery to crush and wash the ore and to separate it from the chert, but prospecting prior to the time of examination had not revealed an ore body sufficiently large to justify the erection of such a mill.

LAING PROSPECT.

The Laing prospect is on the Bud Reynolds place, 2 miles northeast of the village of Newport. (See fig. 18.) The mineral right of the property is owned by the Laing Brothers and at the time of visit (Aug. 29, 1918) work was being done for them by Haven Hoge.

The main group of openings is three-fourths of a mile north of Sinking Creek and is on and near the crest of a hill. The crest of this hill and of others in the vicinity are about 2,600 feet above sea level and apparently mark the level of a former peneplain that has been largely destroyed by erosion. This part of the valley of Sinking Creek, including the hill on which the prospect occurs is underlain by the Knox dolomite which has

yielded a thick residual clay that contains more or less chert. This dolomite is not exposed on the hill on which the prospect occurs but is exposed on the south slope of Sinking Creek Mountain to the northwest. Sandstones of Silurian age with a high dip to the south are exposed higher on the mountain. The field relations at this locality as well as to the southwest and northeast, indicate that the Knox dolomite has been brought into contact with the younger sandstones by a thrust fault from the southeast. The prospect under discussion is in the residual clay and chert of the Knox near this fault. (See fig. 19.)

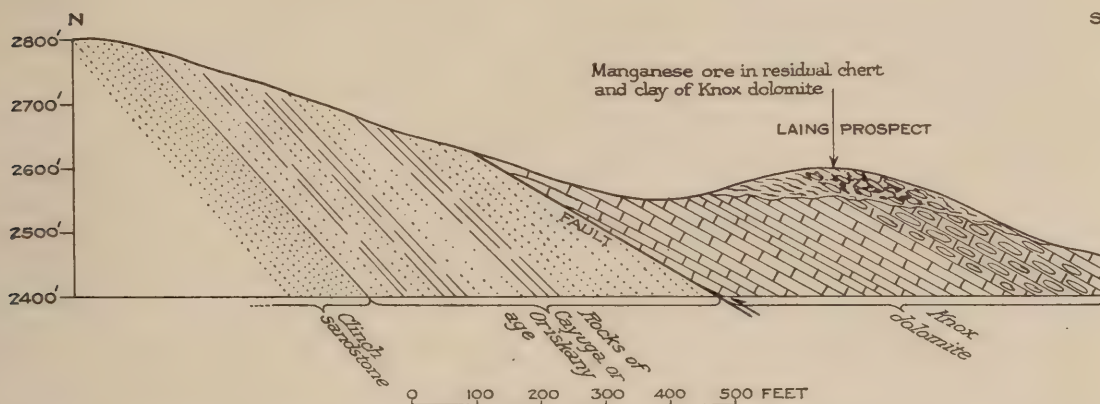


Fig. 19.—Sketch section through the Laing prospect, Giles County, illustrating the occurrence of the deposit of manganese ore.

The openings, which consist of pits and cuts as much as 15 feet deep, have been made over an area of approximately one acre. Red and yellow clays exposed in the pits contain sandstone and chert fragments and there are irregular masses of manganese ore associated with these fragments. A pit 15 feet deep had yielded the greatest quantity of ore. The ore consists of psilomelane and manganite, varies from porous to compact, contains a few fragments of chert and sandstone, and is in masses that vary in size from a fraction of an inch to 200 pounds. At the time of visit close to 7 tons of lump ore, carrying about 45 per cent of manganese, had been hand-picked from the ore-bearing clay and placed by itself on the dump, whereas the finer particles of ore had been left in the clay. The ore-bearing parts of the clay apparently contain ore in the ratio of 1 part of concentrates to 4 or 5 parts of clay, and washing would be required to separate the finer particles from the clay.

It was planned at the time of visit to haul the ore a distance of 10 miles by wagon road to Pembroke where it would be shipped.

Other openings consist of a narrow cut 50 feet long and 8 feet deep at the deepest place and a short tunnel in the side of the cut. These are in a field on the east side of a hollow, south of the main openings and about one-fourth mile north of the main wagon road in Sinking Creek valley. The materials penetrated consist of 2 or 3 feet of rocky red to brown surficial loam and yellow laminated clay which has a high dip to the south. About 200 pounds of psilomelane and manganite in fragments weighing as much as 25 pounds each were observed on the dump. Most of these were apparently obtained from the surficial loam and may have been carried as wash from the above-described deposit higher on the slope to the north. No manganese ore was observed in the laminated clay at the time of visit but the foreman reported the occurrence of a small amount of ore in it.

PRICE PROSPECT.

Float ore occurs on the O. H. Price tract, in the chert hills crossed by the Newport-Pembroke road just west of Newport. The hill is capped by river gravel but its southern slope is largely covered with fragments of chert residual from Knox dolomite with which is associated small pieces of psilomelane and large masses of iron ore. No attempt has been made to prospect for manganese ore, but iron ore was formerly mined to the north-east where Clover Creek cuts through the ridge.

SPRUCE RUN MOUNTAIN PROSPECTS.

EPLING, MOSES, VOIGHT, AND GILLESPIE TRACTS.

Manganese ore float is found on the lower southeast slope of Spruce Run Mountain at numerous places between the Newport-Pembroke road and New River, and much prospecting has been done and some manganese ore has been mined and shipped. Clinch sandstone forms the crest of the mountain and dips southeast beneath sandstones of Cayuga and Oriskany age. Knox dolomite and Ordovician limestone, which underlie Spruce Run valley, have been thrust up against the Oriskany along a fault. Dolomite outcrops at places as high as 450 feet above the valley bottom and red clay soil and chert with manganese ore float derived from the weathered dolomite, form the hills and lower spurs of the mountain up to the bench at 2,500 feet above sea level, which is a remnant of the old valley-floor peneplain of New River and its tributaries. The manganese ore occurs in the deeply weathered dolomite at the level of this peneplain near the above-mentioned fault.

E. L. Arthur, of Pembroke, is reported to hold the option on the mineral right on 97 acres of the mountain slope, including most of the known ore-bearing land. Only the chief opening, which is on the Brade Epling property 2 miles east of Goodwins Ferry, was visited by the writers. Work was being done by Ben Johnson and his son, of Narrows, on a royalty basis, under the Arthur option. A pit 15 feet in diameter with a 15-foot face having a trench outlet on the downhill side had been dug in residual red clay. From the bottom large chunks, 200 pounds in weight, of reniform and pitted psilomelane had been taken out. The cavities in the ore were filled with red clay, which reduced the grade of the ore, and it should be crushed and washed to make it of commercial grade. At the time of visit (Aug. 28, 1918) a carload of ore had been shipped. Mr. Johnson was also prospecting the deposits on the W. H. Moses and Gus Voight tracts to the northeast and another tract adjoining on the southwest.

Some years ago Waggall and Jenkins, of Radford, had mined ore on David Gillespie's farm farther northeast on the mountain slope and a carload of ore was reported to have been shipped on the Norfolk & Western Railway before the Virginian Railroad was built on the east side of New River. The geologic relations are the same as on the Epling property.

DENISON PROSPECT.

An opening has been made on the property of Lyman Denison on the top of Johns Creek Mountain at an altitude of about 3,800 feet, about 2 miles northeast of its southwest end. The prospecting has been done by E. L. Arthur, of Pembroke, in sandstone of Clinton or Cayuga age. The scolithus-bearing sandstones at the top of the Clinton were observed to carry a small quantity of manganese ore on the slopes of Salt Pond and Johns Creek mountains, and the prospect is probably in this or overlying sandstone. The pit was not visited, but samples of small nodular ore from the property, which were shown to the writers, were psilomelane of a good grade.

HERRON PROPERTY.

Float manganese ore was reported on the property of Charles Herron, of Newport, on the south slope of Johns Creek Mountain 1½ miles northeast of the road down the mountain to Newport. The property had not been prospected at the time the writers were in the vicinity, but E. L. Arthur, of Pembroke, was reported to have secured an option with the intention of development. The rocks on the south slope are not known to be man-

ganese-bearing, and it is possible that the float was derived from the ore-bearing beds on the top of the mountain which are prospected on the Denison property.

Similar manganese ore float on the upper southeast slope of Johns Creek Mountain was reported by William Eckols, of Newcastle, farther northeast in Craig County, but no prospecting had been done.

HOGE-LAING PROSPECT.

The Hoge-Laing prospect is 4 miles northeast of Hoges Store, 2 miles northwest of Mountain Lake, and is on the north slope of Doe Mountain, 275 feet below the saddle through which a wagon road passes to the south. (See fig. 18.) Work was being done at the time of visit (Aug 28, 1918) by Haven Hoge, of Hoges Store. At that time 2 wagon loads of hand-picked manganese ore had been hauled to Pembroke, a distance of 8 miles by wagon road, and about 2 tons of ore were still on the dumps of the openings, which were small cuts.

A buff-colored laminated sandstone, which is apparently of Cayuga age, was penetrated in the openings. The sandstone has been extensively crushed so that no measurement of the dip could be made, but it apparently overlies the Scolithus-bearing sandstone at the top of the Clinton formation. Psilomelane and manganite, which are intimately mixed, not only fill fissures along joints and cracks in the sandstone but also occur in the sandstone as replacement material. Most of the ore is free from sand, so that much of it can be separated from the sandstone by hand-picking, but to separate the greater part of it from the sandstone would require crushing and jigging.

SIMPKINS PROSPECT.

The Simpkins prospect is on the W. C. Simpkins place, 2½ miles west-northwest of Interior station, which is on the Potts Valley branch of the Norfolk & Western Railway. (See fig. 18.) This place has been leased by B. C. Banks and H. B. Thompson, of Bluefield, W. Va., and V. L. Miller, of Orchard, W. Va., who made a few openings in November, 1917.

The openings are on or near the crest of a spur of Peters Mountain. A small pit on the east slope of the spur is at an elevation of 2,800 feet above sea level. It was made in a buff-colored, much fractured sandstone, believed to be of Oriskany age, which lies near the axis of a syncline with an east-northeast trend. The openings appear to be near the southwest

end of the syncline (see fig. 20). Manganese oxide in small quantity fills the cracks between the sandstone fragments and has replaced part of the sandstone. The ore is highly siliceous and is reported to run 20 per cent silica.

A shaft, on the crest of the spur at an elevation of 2,960 feet above sea level, is 22 feet deep. It was sunk at the contact of fractured sandstone, dipping 60° E., and purple and underlying white laminated clay which is probably residual from the weathering of limestone of Cayuga or Helderberg age. Psilomelane in small quantity occurs in both the sand-

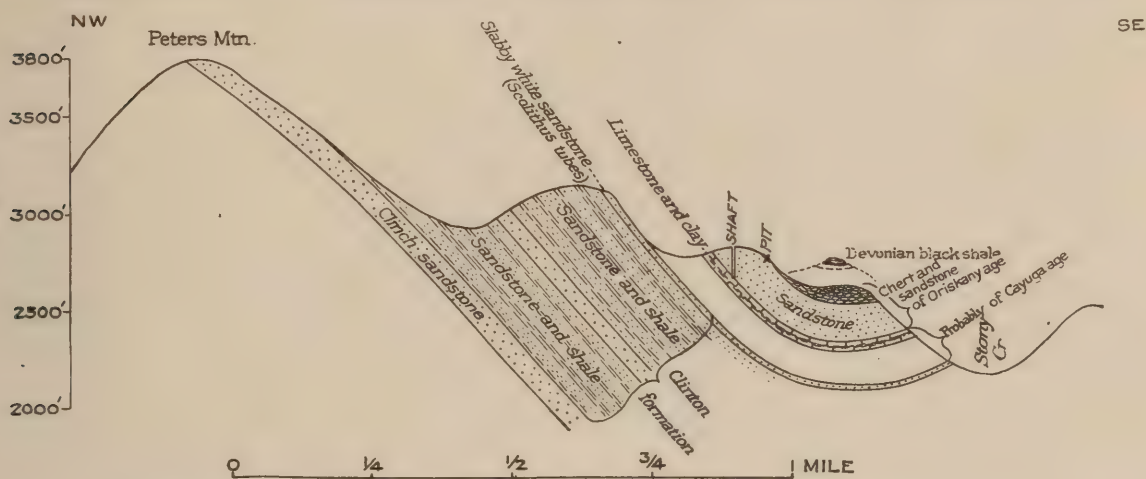


Fig. 20.—Sketch section through the Simpkins prospect, Giles County.

stone and clay more plentifully near their contact. The ore in the sandstone contains much sand, whereas that in the clay is free from it.

A few other openings made by the same parties southwestward along the ore-bearing zone are reported to reveal manganese oxide, but none of them were visited. Fragments of sandstone cemented together by manganese oxide were observed on the surface at a locality on the south slope of a hill just north of the Potts Valley branch of the Norfolk & Western Railway and about half a mile southwest of the above-described shaft. Pits dug by the same parties in the sandstone on the southeast side of the synclinal valley of Stony Creek were reported by Mr. Banks to have exposed very good crystalline ore in small veins in the sandstone, and the slopes below were reported to be strewn with siliceous manganese float ore. These prospects were not visited by the writers.

COLLINS PLACE.

Small pieces of manganese oxide are said to have been picked up on the surface of the J. S. Collins place, about 1 mile west of Interior station.

The pieces in Mr. Collins' possession, which were shown to the writers, consisted of psilomelane and manganite, some of which contained grains of sand. Some prospecting has been done on this place but none of the openings were visited by the writers. The ore is probably in Oriskany sandstone or associated beds.

SNIDOW PROSPECT.

The Snidow prospect, which is on the W. B. Snidow place, is one-fourth mile north of Pembroke station on the Virginian Railroad. A shallow pit was observed on a south hill slope, 30 feet above the alluvial flat of New River. It was dug in buff, yellow, and red clay in which there are fragments of chert and it had yielded about 50 pounds of psilomelane. Other small pits have been made at different places on the property but they revealed only a small quantity of manganese oxide.

The clay and chert in which the psilomelane occurs are residual from the Knox dolomite, and are overlain on the hillslope by gravels and cobbles which have been washed down from the stream deposits on the top of the hill.

EATON PROPERTY.

Manganese float ore was reported on the property of Boyd Eaton, 2 miles west of Staffordsville. The area is underlain by Knox dolomite and the ore is undoubtedly associated with its residual clay and chert. Specimens of the ore were reported to be of high grade, and to contain 52.4 per cent manganese. No prospecting had been done and the property was not visited by the writers.

SHORT MOUNTAIN PROSPECT.

Manganese ore is reported on Rollie Johnson's place on Short Mountain, west of Clendening Creek, 3 miles north of Pearisburg. Several pits from which iron ore had been mined many years ago were visited. The iron ore fills brecciated sandstone and chert of Oriskany age, and probably manganese oxide is associated with it or takes its place in some areas, but none was seen by the writers. These rocks dip 30° to 50° S., and are folded into a closely compressed syncline which incloses Devonian black shale in the valley between Short Mountain and Peters Mountain. Knox dolomite and Ordovician limestone which underlie the valley south of the mountains are thrust against Clinch sandstone along a fault at the foot of Short Mountain.

LINKOUS AND SHUMATE PROSPECT.

Manganese ore is reported on the Linkous and Shumate property up the hollow northwest of Shumate station on the New River, Holston & Western Railroad, about 2 miles west of Narrows. (See fig. 21.) It is said to lie below chert of Oriskany age on the northwest slope of Piney Mountain, a foothill of East River Mountain. A few small pits are reported to have been dug, from which small masses of ore were plentifully obtained, specimens of which were examined by the writers and found to be good-grade dense psilomelane, but the property was not visited.



Fig. 21.—Map of the southwestern part of Giles County and the eastern part of Bland County, showing the location of the manganese mines and prospects.

STOWE MINE.

The Stowe mine is on the southeast slope of Piney Mountain, a foothill of East River Mountain, 4 miles southwest of Narrows on the Norfolk & Western Railway. (See fig. 21.) It is on the property of Ada Wilbur, of Thessalia, and is about 2 miles up the hollow northeast of French station on the New River, Holston & Western Railroad. The openings consist of many shallow pits and trenches from 2,330 to 2,550 feet above sea level, on or near the surface of a bench on the mountain side. This bench is 2,400 feet above sea level and represents the old valley-floor peneplain of New River and its tributaries.

NW

SE

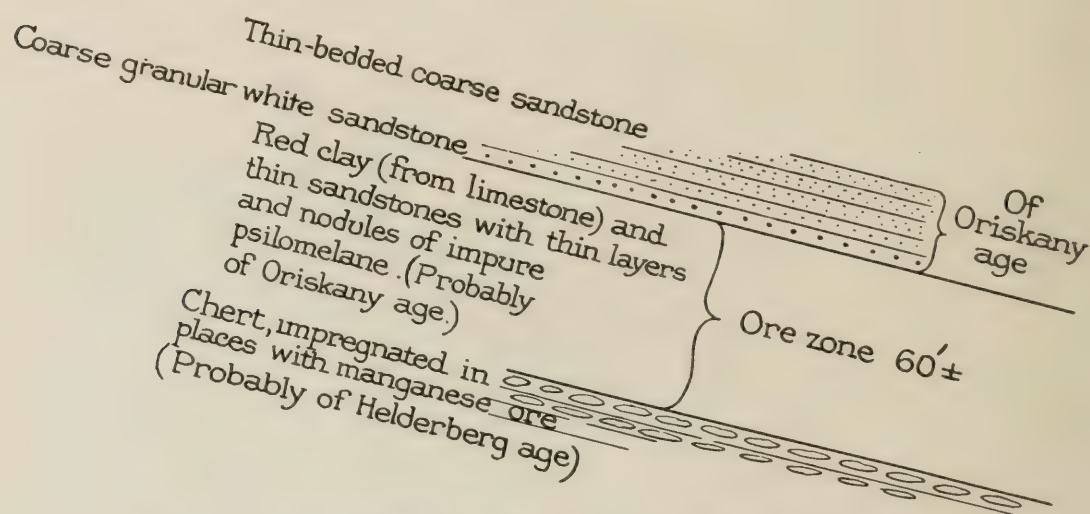


Fig. 22.—Cross section of the Stowe mine workings, Giles County.

The mine was opened by Audrey Hart Stowe, formerly of Pocahontas, W. Va., early in 1918, who leased 1,200 acres on a royalty basis. He operated the mine under the name Vest, Stowe & Co. A few months before the time of visit (Aug. 21, 1918), one carload of 19 tons of ore had been shipped and 30 tons of ore was being hauled down the mountain to the railroad for shipment. The shipped ore is reported to have analyzed 32 per cent manganese, 2 per cent iron, and 24 per cent silica. The ore on the dump was apparently of similar low grade, in keeping with this analysis. Much of it is nodular psilomelane, with a dull luster on fractured surfaces, and is ribbed with impurities. Many nodules have turreted and other odd surface forms and some show secondary filling in shrinkage crevices of purer psilomelane. (See Plates XI and XII.)

Wolf Creek Valley is underlain by Knox dolomite and Ordovician limestone which are thrust up against Devonian rocks along a fault on the

southeast slope of East River Mountain. Clinch sandstone, which forms the crest of the mountains, and the overlying Silurian and Devonian rocks dip southeast down the slope.

The ore is in shaly sandstone and clay which are derived from weathered limestone and which overlie a massive chert dipping 45° SE. down the slope. (See fig. 22.) These rocks are believed to be of Oriskany age, although no fossils were obtained. From 2,330 feet to 2,450 feet above sea level shallow trenches along the side of the ravine over a distance of 400 feet expose sandy wash containing irregular chunks of earthy ore, which rests on interbedded sticky yellow clay and yellow sand containing a little platy psilomelane. These beds are apparently residual from limestone and sandstone in place. A massive bed of hard chert lies 8 to 10 feet below in the stream bed, and a thicker granular white sandstone bed outcrops on the slope above. One trench in the ravine, larger than the rest, was the source of most of the ore. It is 6 to 8 feet wide, 5 feet deep and about 100 feet long. Numerous pits on the slope above the trench expose sandstone beds and sandy wash, all more or less impregnated with psilomelane.

HARE PROSPECT.

The Hare prospect is $1\frac{1}{2}$ miles north of Chapel postoffice and station on the New River, Holston & Western Railroad and is on the R. F. Hare place, though the iron and manganese ore rights are owned by W. W. McNeal and J. W. Kessler, of Bluefield, W. Va. Prospecting for these ores was done in 1917 by Messrs. McNeal and Kessler, but no ore had been shipped before the time of visit (Aug. 26, 1918). Some iron ore has, however, been shipped since then.

The prospect is on the crest of a southern foothill of East River Mountain and is about 1,100 feet above the railroad at Chapel. The principal openings, which are shown on the accompanying sketch (fig. 23), consist of a cut 40 feet long, about 6 feet wide, and 15 feet deep at the northwest end, trending N. 65° W., and a northeast-southwest cut of about the same size. The cut to the east was made in a hard, massive, coarse-grained, cross-bedded red and yellow sandstone, which is apparently the top of the Clinton formation. A part of the west cut was made in the same sandstone but the north end of it was made in red sandstone and shale which are in the upper part of the Clinton formation. The beds here strike N. 65° W., and dip 70° to the southwest. The west cut reveals a 2-foot bed of brown iron ore of a good quality lying parallel with the bedding at the con-

tact of the massive sandstone and the red rocks of the Clinton formation. About 60 tons of ore had been taken from this bed and was on the dump at the time of visit.

The east cut followed a 6-foot zone of sandstone that has been partly replaced by psilomelane and brown iron oxide, and the west cut penetrated

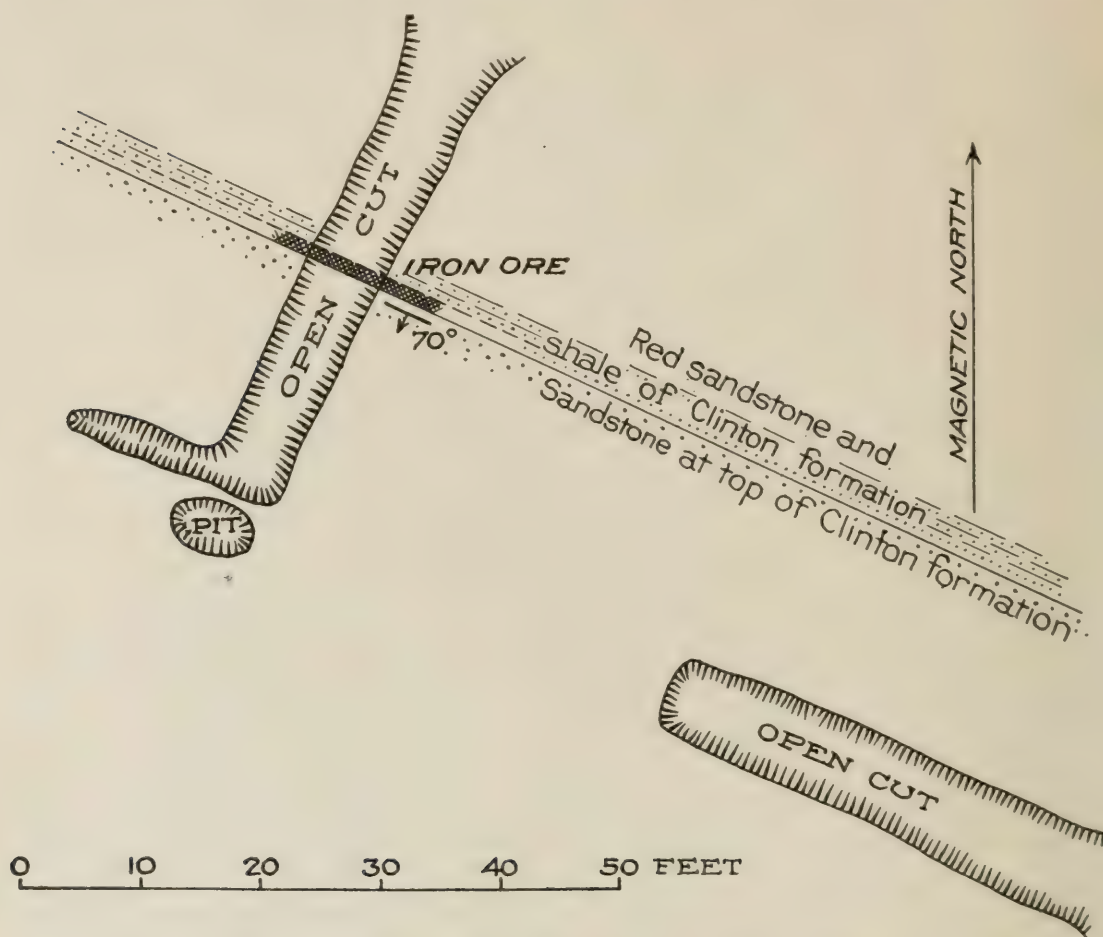


Fig. 23.—Plan of the Hare prospect, Giles County.

a continuation of the same zone. This zone is parallel with the bedding and is about 20 feet above the base of the massive sandstone. The psilomelane and iron oxides are more or less intermixed, they are not in large quantity, and they contain much sand, as the replacement of the sandstone was not complete.

A shallow pit that is farther north reveals a bed of brown iron ore, 14 feet thick, in the Clinton formation. Although most of the ore bed contains some quartz sand, the iron content may be sufficiently high for the ore to be mined if further prospecting proves the bed to be of wide extent.

BEAMER PROSPECT.

The Beamer prospect is on the L. B. Beamer place $1\frac{1}{2}$ miles north-northeast of Chapel. This place has been leased by Judge Martin Williams, W. C. Crockett, and Mr. Farrier, of Pearisburg, who were doing prospect work at the time of visit (Aug. 26, 1918).

The main opening is a northwest-southeast cut, 75 feet long, in the head of a southward-trending hollow and is about 1,000 feet above the railroad at Chapel. It was made in red flaggy sandstone and weathered shale of the Clinton formation, which dip 30° NE. Three pockets and veins, as much as a few inches thick, of porous steel-blue psilomelane and wad had been found in the sandstone and weathered shale before the time of visit and about 1,000 pounds of these minerals had been obtained and placed on the dumps. The quantity of these ore minerals is very small in comparison with the quantity of waste material that has been removed from the cut. As they contain cavities filled with clay, crushing and washing would be required to produce a high-grade manganese ore from them.

A second cut has been made one-fourth mile to the west. It is on the south slope of a ridge whose crest is produced by the massive gray sandstone of Clinton age. These beds dip at a very high angle to the north and strike east. The cut, which is small, has been made along the contact of the massive gray sandstone and the red rocks of Clinton age and revealed considerable brown iron ore but only a very small quantity of manganese oxide. A small pit that is south of the main opening has revealed brown iron ore and a small quantity of manganese oxide.

NO BUSINESS CREEK PROSPECT.

A manganese-ore prospect which is on the property owned by Ottomar Stange is on the west end of a low ridge on the south side of No Business Creek about 3 miles due south of Chapel station on the New River, Holston & Western R. R., and the same distance east of the south end of the incline railroad that runs across Wolf Creek Mountain from First Ford station. (See fig. 21.) The ridge on which the prospect occurs has not been named; it is just south of Middle Ridge.

Only one or two shallow pits had been made at this locality before the time of visit (Aug. 2, 1920) so that the nature of the manganese-ore deposit was determined so far as possible from the surficial materials. Masses of psilomelane, manganite, and brown iron oxide, some of which weigh a few hundred pounds were observed on the surface over an area of

several acres on the west end of the ridge. These minerals are generally though not everywhere intermixed, and the iron is apparently in greater amount than the manganese, so that the ore thus observed on the surface is a manganiferous iron ore. Prospecting may show the ore to extend some distance below the surface and may also show the percentage of manganese to increase downward.

There are no rock outcrops in the area where the masses of the above-mentioned minerals are most numerous, but the occurrence on the surface of fragments of a fine-grained gray sandstone which are cut by thin veins of these minerals indicates that sandstone is the ore-bearing rock at this locality. Outcrops of sandstone beds, probably of Oriskany age, occur lower on the slopes to the west and north. There the sandstone dips at low angles to the west indicating that the west end of the ridge is a dip slope. The absence of manganese and iron minerals, except in very small quantity in the exposed sandstone, indicates that further prospecting should be confined to the parts of the slopes that are higher than the sandstone outcrops.

The surface indications at this locality suggest that a fairly large deposit of manganese ore or manganiferous iron ore of good quality will be discovered by further prospecting.

FLAT TOP PROSPECTS.

A small pit has been dug in yellow sand by the roadside on the crest of Flat Top Mountain about $1\frac{1}{2}$ miles northeast of the Johnson prospect. (See fig. 21.) Fragments of manganese oxides, some of which contain grains of quartz, occur on the surface at this locality and the pit was dug in order to determine whether or not the ore is merely surficial. A small pile of such fragments lying near the pit were apparently found in the pit.

Good manganese float ore and iron ore in moderate quantity were seen by the writers at other places on the top of Flat Top Mountain, especially on the 3,500-foot peak about 1 mile northeast of the pit just described, a short distance from the junction with Sugar Run Mountain. The rocks at the surface here appear to be Oriskany sandstone. Similar ore was also seen about three-quarters of a mile southwest of the Johnson prospect. The larger ore fragments had been gathered into small piles and appeared to be of good quality except for contained quartz grains. The

Stange Mining Co. was expecting to prospect several of these ore blooms which are on the property of the Bland County Lumber Co.

JOHNSON PROSPECT

The Johnson prospect, which is on property owned by A. A. Miller, B. T. Johnson, and Hubbard Hale, of Narrows, Va., is on a spur of Flat Top Mountain about 9 miles southwest of Narrows, and about 1 mile northeast of the Stange mine. Prospecting was begun at this locality in 1917 and was in progress at the time of visit (Aug. 20, 1918). At that time about 15 tons of ore that was said to have been picked up on the surface at different places on the property had been hauled a distance of 14 miles by wagon road to South Gap station on the New River, Holston & Western Railroad for shipment.

The prospect is on the crest of a low nearly east-west ridge and is about one-eighth mile north of the East Fork of Ding Branch and 100 feet above the branch. It consists of an L-shaped cut, whose longer arm—a narrow cut 80 feet long—runs N. 20° W. into the hill and whose shorter arm, 10 to 20 feet wide, 30 feet long, and 12 feet deep, trends N. 20° E. from the north end of the longer arm. The cut has been dug in soft yellow sandstone and sandy clay, which dip about 45° SSE., and at one place in the cut a lens of chert 1 inch thick was exposed. These beds are probably of Cayuga age. Manganese oxides have been found in small quantity in a bed of yellow and brown clay 2 feet thick, and at the time of visit it was being washed by hand at the East Fork of Ding Branch. The ore is of low grade and small in quantity.

THOMPSON PLACE.

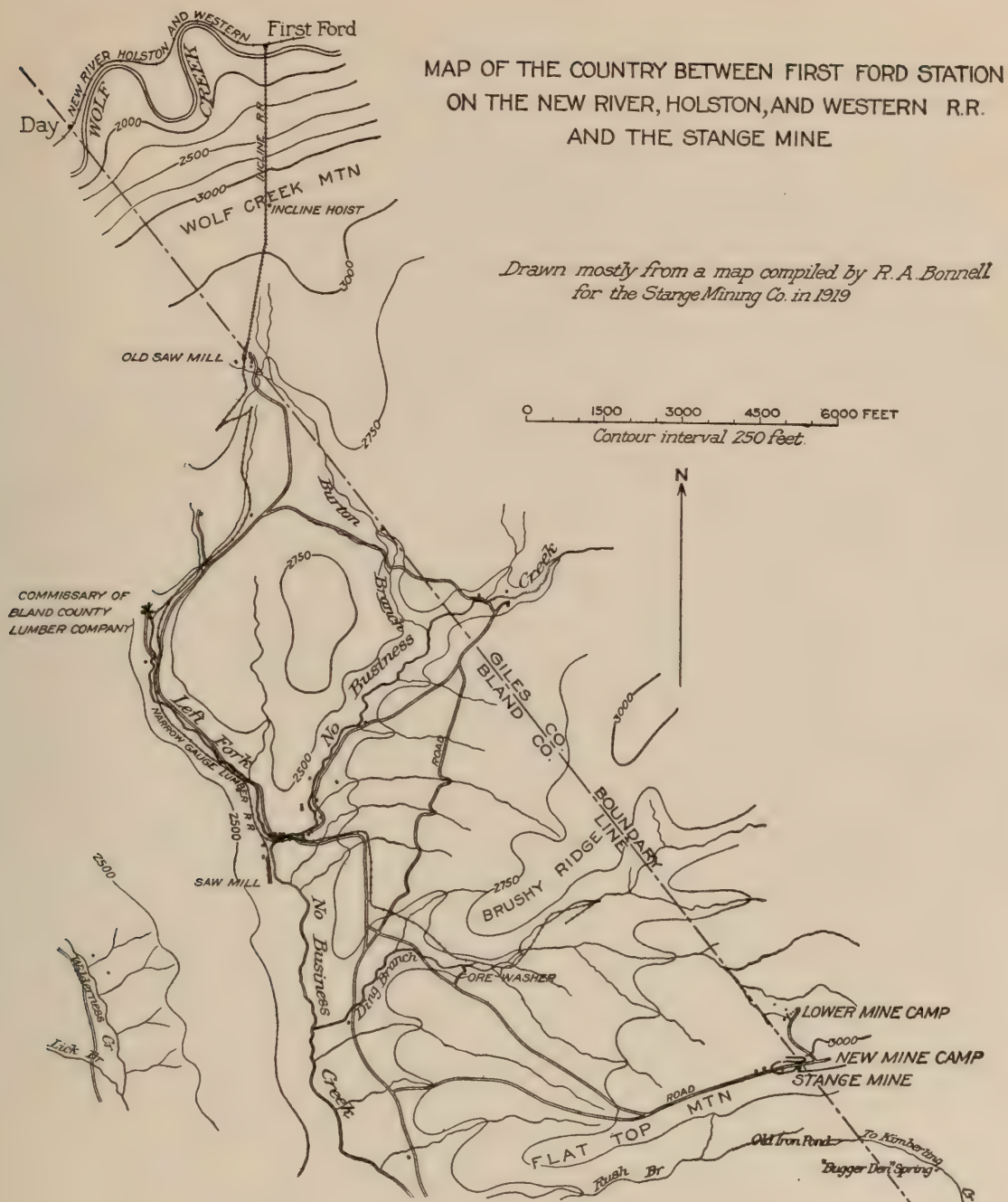
The R. P. Thompson place is on the southeast slope of Flat Top Mountain 1 mile northeast of the Stange mine. Fragments of manganese oxides weighing a fraction of a pound were observed in sandy clay near Mr. Thompson's spring just west of his house and fragments of such oxides weighing a few pounds each were observed on the surface one-fourth mile northeast of his house. The fragments of these oxides at both places contain much sand and although prospecting might reveal ore freer of sand below the surface, it is not likely that ore in commercial quantity will be discovered, especially at the locality near the spring.

No prospecting had been done on Mr. Thompson's place prior to the time of visit (Aug. 2, 1920).

GILES AND BLAND COUNTIES.**STANGE MINE.**

Location, history, and production.—The Stange mine, also known as the Flat Top mine, is on the crest of Flat Top Mountain 10 miles in a straight line southwest of Narrows, and is partly in Giles County and partly in Bland County, the line between these two counties passing through the mine. (See fig. 21.) It can be reached best by going to First Ford station on the New River, Holston & Western Railroad, then taking the narrow-gauge incline railroad of the Bland County Lumber Co., over the top of Wolf Creek Mountain to the south and next going by wagon road a distance of about $4\frac{3}{4}$ miles in a southeastward direction. (See Pl. XXIV.) It can also be reached by automobile from Pearisburg by way of Poplar Hill, thence up Walker and Kimberling creeks.

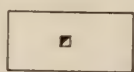
The property, which covers 27,500 acres of what was once known as the Angels Rest Survey, was formerly owned by Ben T. Johnson, of Narrows. The mine was first worked in 1917 by Ben T. Johnson and his sons under the name Johnson Bros. and Co. They shipped five carloads of manganese ore from June to September of that year, the first two being hauled to the railroad at South Gap, the rest to the foot of the incline over Wolf Creek Mountain to First Ford. This ore was shipped to furnaces at Granite City and East St. Louis, Ill., and Alliance, O. In the fall of 1917 E. S. Suffern, of New York City, bought the mineral rights and operated the mine until the summer of 1918. He built an extensive mining camp near the mine, established the Crandon post-office at the company office, and mined and shipped about 900 tons of manganese ore. Early in the summer of 1918 the mine and mineral rights were sold to Ottomar Stange, of Pittsburgh, Pa., who operated it under the name of the Stange Mining Co., Inc. This company built a washing plant on Ding Branch $1\frac{1}{4}$ miles north-northwest of the mine and also built $3\frac{1}{2}$ miles of narrow gauge railroad running from the plant to the south end of the incline railroad that crosses Wolf Creek Mountain. The company, however, was unable to complete these improvements until about the time the armistice with Germany was signed (Nov. 11, 1918). At that time the demand for domestic manganese ores practically ceased. Some of the ore that has been marketed since then was sold under war-time contracts. Such a contract was held by C. G. Chevalier, of Baltimore, and under arrangement with the Stange Mining Co., he began the operation of the mine and washing plant in November, 1918, and continued their operation until the contract expired at



EXPLANATION



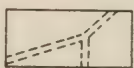
Open-cut



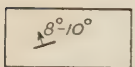
Shaft or pit



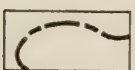
Mine dump



Secondary road

Strike and dip
of rock strata

Trail

Approximate boundary
of area within which
manganese ore oc-
curs on surfaceSection along A-B
shown in Fig. 25

· MAP OF THE STANGE MINE ·
ON FLAT TOP MOUNTAIN, GILES AND BLAND COUNTIES

From planetable survey by H. D. Miser.
July 1920

0 500 1000 FEET
Contour interval 10 feet Datum is mean sea level

The elevation of Station No. 1 is the mean of two readings of aneroid barometers in 1918.
From this station all other elevations were determined by means of vertical angles and
stadia measurements.

the end of May, 1919, during which time slightly more than 1,000 tons of manganese ore was marketed. The mine has remained idle since June 1, 1919. There has been some litigation over the ownership of the mine, the south part of the mine being claimed by heirs of the Burns estate, and the last mining by the Stange Mining Co. was restricted to the northern part.

Workings.—The workings are on and near the crest of Flat Top Mountain, the lowest of them being about 40 feet below the crest. The mountain at this locality is a ridge that trends S. 80° W., and its crest is about 2,990 feet above sea level at the west end of the mine and 3,017 feet above sea level at the east end. This surface may be part of the old summit peneplain. The principal workings are three cuts, herein called the North, Middle, and South cuts. (See Pl. XXV.) Other prospect openings include two short tunnels on the south side of the North cut, a few shallow pits, and a drill hole 72 or 73 feet deep which is on the mountain crest. The North cut, which is on the north side of the crest, trends nearly east and west and is about 250 feet long, as much as 60 feet wide and about 30 feet deep. (See Pl. XXVI.) The South cut, 600 feet long, follows the south slope of the mountain and its north face at places is as much as 12 to 15 feet high. The Middle cut runs 150 feet northeast from the South cut; it averages 40 feet in width and the face at the north end where it is highest is between 20 and 25 feet high.

Geology.—The manganese-ore deposit is in sandstone of Oriskany or Cayuga age. The sandstone is revealed in the workings but is also exposed on the surface, though at most places on the surface it is concealed by a few inches or more of loose material that consists of sand, fragments of sandstone, and masses of manganese ore. In the South and Middle cuts there are pockets of ore and sandstone fragments as much as 12 feet wide, which extend from the surface downward 20 feet or more into the hard sandstone. They are believed to be zones of fissuring and crushing in the anticlinal arch of sandstone which have been impregnated with ore, and they were apparently in part formed by the residual component materials accumulating in fissures as the rock weathered. (See fig. 24.) A vein of red clay a few inches to 1½ feet wide which cuts across the bedding of the sandstone was observed at the east end of the North cut. The clay in it and that along some joints in the sandstone were obviously washed into fissures in the sandstone, but a bed of sticky clay 6 inches to 3 feet thick

called "buck fat," which was found in the lower part of the North cut, may have been derived from a bed of limestone that once occupied the present position of the clay.

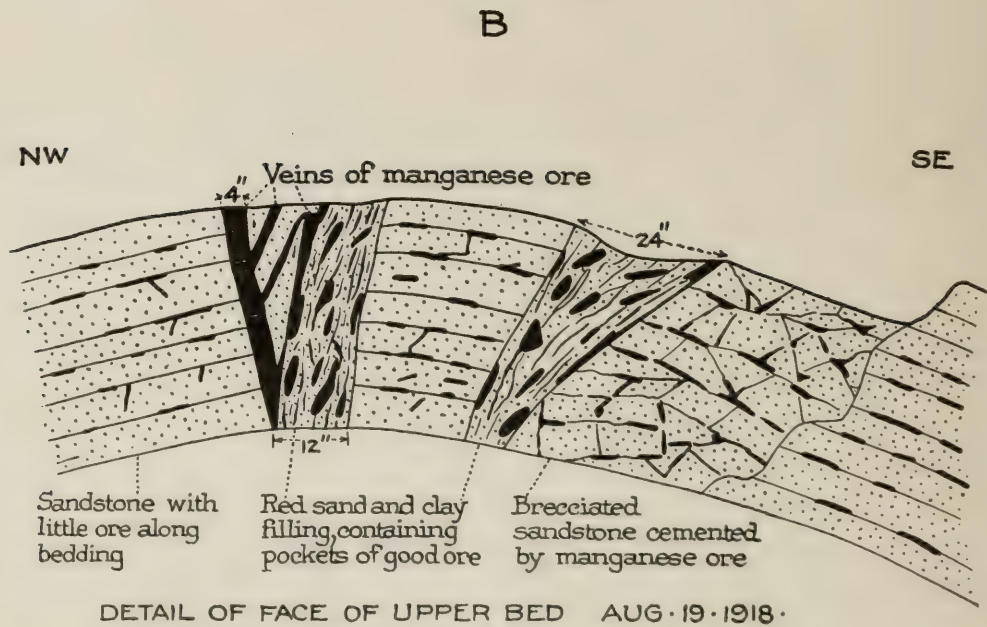
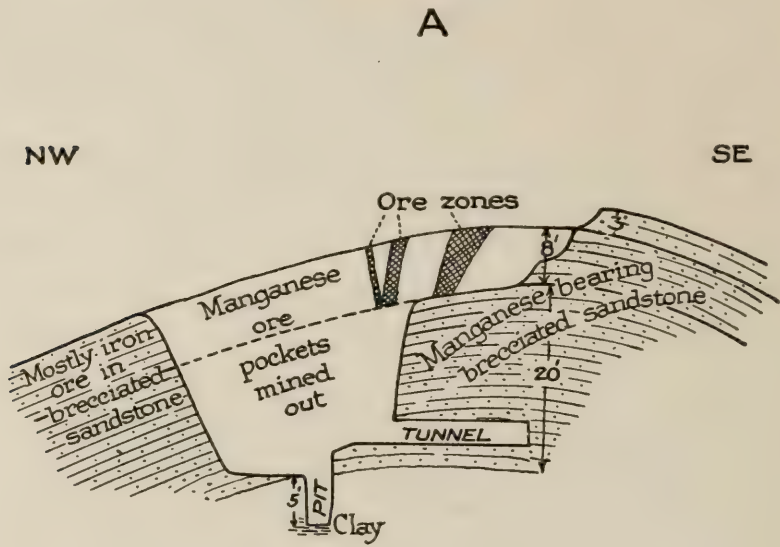


Fig. 24.—Sketch cross section (A) of North cut of Stange mine on Aug. 19, 1918, and detailed sketch (B) of fractured upper bed in east face of pit, showing mineralization of the sandstone.



(A) North cut of Strange mine, Giles and Bland counties, in August, 1918.



(B) East face of north cut of Stange mine, Giles and Bland counties, in August, 1918.

Most of the sandstone in which the manganese-ore deposit occurs is massive, shows lamination and cross bedding, consists of quartz grains of medium size, and is white to cream in color, though a small part of it is stained red and rusty. At some places it contains well-rounded quartz pebbles one-fourth inch or less in diameter. The lowermost beds of sandstone which have been encountered in the North cut and in the bottom of the north end of the Middle cut are very fine-grained and earthy or clayey, and for this reason have been called "clay" by the miners. Parts of the earthy sandstone contain fossils.

The sandstone has been cut by numerous joints, and parts of it have been crushed into fragments of large and small size, so that at many places the bedding has been obliterated. This is especially well shown in the face and walls of the Middle cut. One of the fractured zones has been followed to the east by the North cut.

The sandstone on the north side of the North cut dips at low angles to the north, whereas that on the south side dips to the south at angles ranging from a few degrees to 40° , the lowest dips being at the east end and the highest at the west end of the cut. This cut, therefore, follows the crest of an anticline. (See fig. 25.) That a syncline, although one of small size, lies just south of the North cut is shown by northward dips in the Middle cut. That these folds are minor ones and are located on the crest of a large anticline whose crest or axis follows the crest of the mountain, is shown by the dips of the rocks both north and south of the workings. A bed of coarse-grained, pebbly, ledge-making sandstone several feet thick, which overlies the beds of sandstone that contain the manganese ore, caps the part of the mountain crest on which the water tank stands and also caps the short spur northwest of the tank. It dips 8 to 10° to the north and the crest of the spur is a dip slope. The same bed of sandstone caps the mountain crest at and just north of the stable where the dip is about 10° to the north and it crops out on the south slope of the mountain where the dip is 40° to the south. The approximate location of the base of this sandstone, which is of Oriskany age, is represented on the map of the mine (Plate XXV.) Overlying chert, also of Oriskany age, is the surface formation just south of the coarse sandstone. The ore-bearing sandstone is either a lower bed in the Oriskany or is of Cayuga age. The structure of Flat Top Mountain at the mine is illustrated in figure 25.

Manganese-ore deposit.—The manganese-ore deposit is on the crest of the major anticline. Masses of ore on the surface, together with the occurrence of ore in the mine openings, show that the deposit extends at least

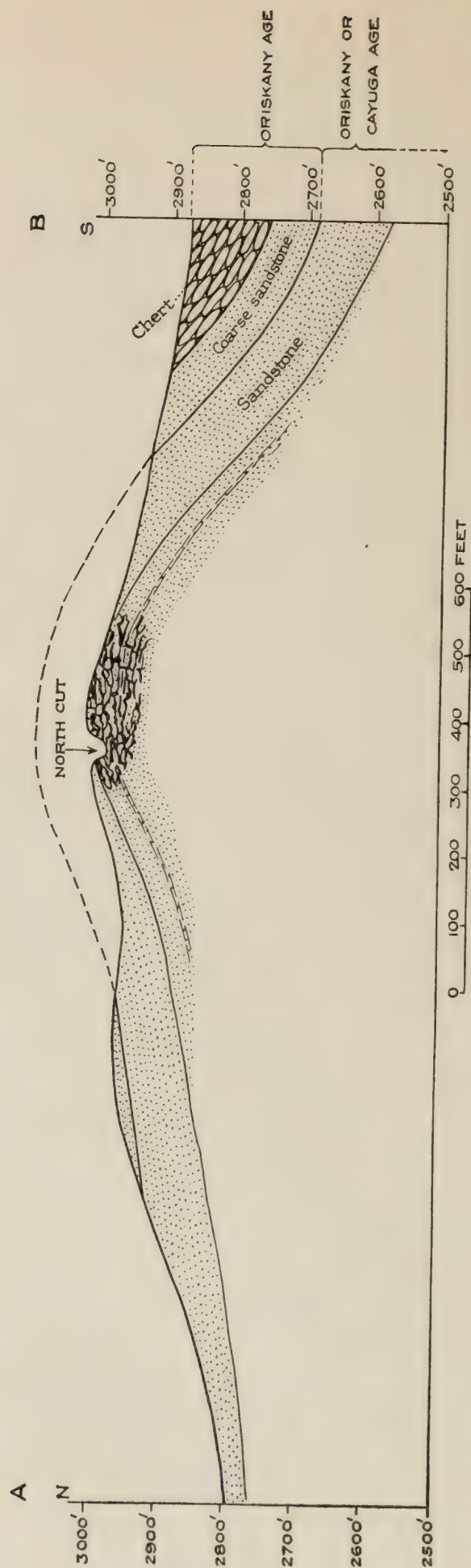
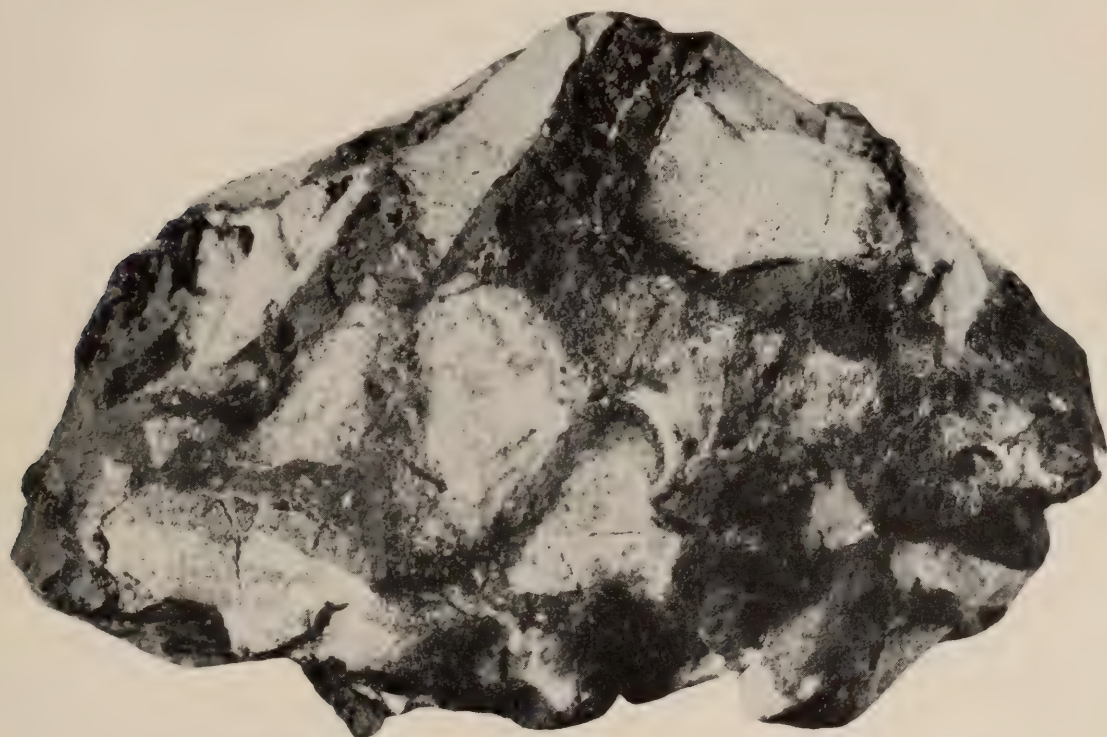


Fig. 25.—Geologic cross section through the Stange mine, Bland and Giles counties, along the line marked A-B on Plate XXV, illustrating the structure of Flat Top Mountain and the occurrence of the deposit of manganese ore at that mine.



(A) Sawed face of specimen showing sandstone fragments of breccia that have been cemented together by pyrolusite and partly replaced by that mineral. Stange mine, Giles and Bland counties.



(B) Breccia composed of sandstone fragments cemented together by manganese oxides and only slightly replaced by ore. Stange mine, Giles and Bland counties.

from the east end of the North cut to the west end of the South cut—a distance of 700 feet—and the openings show that it has a north-south width of about 300 feet. The openings visible at the last visit (July, 1920) do not show the deposit to be so wide, but there are many small openings on the south slope that have been concealed by the large dump just south of the South cut; these were examined at the time of the first visit (Aug. 19 and 20, 1918). Some masses of ore are, however, found on the surface as far west as the stable and are found in the wagon road to the south border of the area represented on the map. The greatest depth to which the ore body has been penetrated by openings is about 40 feet, but a drill hole 72 or 73 feet deep on the mountain crest is said by Mr. Stange to have found ore from the surface to the bottom and not to have passed below it. The manganese minerals include psilomelane, pyrolusite, and manganite. Of these, psilomelane is most abundant at and near the surface, whereas pyrolusite is the chief mineral in the deeper workings. Pyrolusite and manganite occur as plumose crystals in the psilomelane and as small single crystals and fibrous radiating crystals that line cavities in it, and many masses of ore may be obtained that consist entirely of fine-grained pyrolusite. These minerals occur as breccia filling in the crushed parts of the sandstone and as veins along joints and bedding planes. They have to some extent filled fissures between the sandstone fragments but they have for the most part replaced the sandstone. (See Pl. XXVII.) The replacement of the sandstone by manganese minerals is especially conspicuous in the earthy fine-grained sandstone in the North cut. There the manganese minerals have penetrated all parts of the sandstone away from the joints and bedding planes and inclose irregular areas of unreplaced sandstone. Iron oxide occurs at a few places but is confined almost entirely to the north side of the North cut, where there is very little manganese ore associated with it. The pyrolusite is mostly firm; only a very small part of it falls to a fine powder when it is exposed to weathering. During the operation of the mine by the Stange Mining Co., about 50 tons of pyrolusite was saved by hand-picking, so as to be shipped separately, but on account of certain conditions not known by the writers it was finally mixed with other ore consisting largely of psilomelane and manganite and was shipped with them. A considerable proportion of the future output of the mine will doubtless be pyrolusite suitable for dry batteries and chemical purposes. A partial analysis of this mineral from this mine follows:

Partial analysis of pyrolusite from the Stange mine.

[J. G. Fairchild, of U. S. Geological Survey, analyst.]

Manganese dioxide (MnO ₂)	85.0
Manganese protoxide (MnO)	2.9
Baryta (BaO)	(a)
H ₂ O—	.04
H ₂ O+	2.56
	90.64

(a) An appreciable amount of baryta was noted but the quantity was not determined.

The veins and pockets of ore vary greatly in size, generally being less than a foot wide but one large pocket yielded 30 tons of ore. The ore is distributed through practically all parts of the sandstone revealed in the openings, but is more abundant at some places than at others. Four tons of ore-bearing sandstone as exposed in the openings will probably yield an average of one ton of marketable ore. Only the richer parts of the ore were treated in the washing plant of the Stange Mining Co., and these are said by Mr. Stange to have yielded one ton of concentrates from two tons of ore-bearing sandstone. The leaner parts of the mined ore were placed on the dumps and these will doubtless be worked over whenever near-by railroad transportation is available.

A deposit of manganese ore on Flat Top Mountain, which is apparently the same as that at the Stange mine, was described 40 years ago by C. R. Boyd¹ as follows:

¹ Boyd, C. R., Resources of southwest Virginia, pp. 147-148, John Wiley & Sons, New York, 1881.

"Manganese ores seem to be confined almost exclusively to the Oriskany measures. In fact, the iron ore of those rocks frequently gives way almost entirely to oxide of manganese.

"At one point in these rocks on Flat Top Mountain, near the line between Giles and Bland counties, the ore was found in great purity, giving the following measures, etc.: Trend north 70° east, dip 60° north 20° west, containing valuable quantities of manganese disseminated heavily through sandstone, five hundred yards in length, gradually becoming impregnated with iron as you approach the eastern end. The apparent width of the ore strata is here extraordinary, and may be owing to a duplication of strata from end pressure, or flexure, or a mere fold. It is 240 feet through. Elevation of outcrop above water level in Kimberling Creek is 1,200 feet; vein would no doubt strip well.

"Analysis of manganese ore as follows:

Analysis of manganese ore.

"Red oxide of manganese [Mn ₂ O ₃ ?]	84.34 ^[a]
Oxygen [O]	3.73 ^[a]
Protoxide of cobalt [CoO]	.68
Alumina [Al ₂ O ₃]	1.80
Lime [CaO]	.32
Silica [SiO ₂]	.21
Baryta [BaO]	7.21
Water [H ₂ O]	1.71

(Signed) H. DICKINSON.

^a These percentages were apparently calculated after the percentages of manganese and available oxygen were determined.

“This analysis being made out by Mr. Dickinson in close technical form, gives 59.215 p. c. of metallic manganese, 23.53 p. c. of combined oxygen, and 3.73 of oxygen recognized as otherwise disposed in the ore.”

The accompanying analyses represent the composition of some of the carload shipments by E. S. Suffern and all of the shipments of the Stange Mining Co.

Analyses of carload shipments of manganese ore from the Stange mine.

	Date of shipment.	Manganese. (Mn)	Phosphorus. (P)	Silica. (SiO ₂)	Moisture.
1	Nov. 20, 1917	35.215	.346	16.57	.....
2	Nov. 24, 1917	31.368	.274	26.36	.....
3	Nov. 29, 1917	34.574	.305	19.52	.....
4	Dec. 3, 1917	29.723	.342	28.67	.....
5	Dec. 6, 1917	30.817	.272	27.68	.....
6	Dec. 20, 1917	36.383	.254	21.92	.....
7	Feb. 12, 1918	49.01	.....	.....	.....
8	Feb. 16, 1918	49.01	.....	.....	.....
9	Feb. 22, 1918	49.01	.....	.....	.....
10	Mar. 20, 1918	53.93	.....	7.52	.....
11	Apr. 1, 1918	53.93	.....	7.52	.....
12	Apr. 11, 1918	51.84	.....	11.04	.....
13	Apr. 27, 1918	46.51	.246	18.00	.....
14	Apr. 29, 1918	54.29	.285	7.96	.....
15	May 18, 1918	51.20	.174	10.08	.....
16	Nov. 30, 1918 (3 cars)	47.36	.230	11.00	3.76
17	Feb. 15, 1919	47.50	.232	7.90	3.30
18	Mar. 3, 1919	44.64	.240	15.00	3.70
19	Mar. 8, 1919	47.70	.238	9.50	4.40
20	Mar. 22, 1919	47.30	.228	12.15	5.00
21	Mar. 29, 1919	46.20	.255	12.10	2.50
22	Apr. 3, 1919	46.55	.251	12.30	3.50
23	Apr. 8, 1919	46.30	.249	11.50	4.40
24	Apr. 12, 1919	47.30	.220	9.00	4.80
25	Apr. 17, 1919	46.20	.248	11.60	4.20
26	Apr. 19, 1919	47.10	.235	7.70	5.00
27	Apr. 24, 1919	47.60	.254	8.00	6.80
28	Apr. 28, 1919	49.50	.235	5.65	3.50
29	May 3, 1919	48.90	.236	6.25	3.10
30	May 8, 1919	45.50	.240	9.40	4.20
31	May 12, 1919	47.67	.247	8.10	5.00
32	May 20, 1919	51.50	.224	4.00	1.30
33	May 22, 1919	48.88	.247	4.80	3.20
34	May 26, 1919	50.00	.246	6.60	2.50
35	May 28, 1919	45.30	.249	8.90	2.20
36	May 31, 1919	45.55	.240	10.50	2.20
37	May 31, 1919	46.10	.238	9.20	4.80
38	May 31, 1919	41.70	.171	14.40	5.90

- 1-15. Mined and shipped by E. S. Suffern.
- 16. Mined and shipped by Stange Mining Co. to furnace of Miami Metals Co., Goshen, Va.
- 17-38. Mined and shipped by Stange Mining Co. to Carnegie Steel Co.

Mining and preparation of ore.—The friable nature of the ore-bearing sandstone makes easy the separation of the ore from the sandstone by means of crushing and washing. The blows of a hammer will cause much of the sandstone to disintegrate completely to sand, and exposure of the sandstone to weathering will also cause much of it to disintegrate in this way. A large part of the ore-bearing sandstone that has been placed on the dumps was disintegrated, leaving the ore comparatively free from sand. Sand, however, is disseminated through some of the ore and its separation is not feasible. The presence of sand in some of the marketed ore is indicated by the high silica contents as given in the accompanying analyses of carload shipments.

The manganese ore that was shipped by B. T. Johnson and Sons and by Mr. Suffern was picked up on the surface or mined by hand in open cuts and was marketed after being only hand-picked. Ore was mined by the Stange Mining Co. by means of a steam shovel, then hauled in wagons a distance of $1\frac{1}{4}$ miles to the washing plant on Ding Branch, which was almost 800 feet lower than the mine. The washing plant was equipped with a double log washer and a picking belt. All of the marketed ore was run through it except the larger lumps of pure ore which were hand-picked. The concentrates were hauled in tram cars from the plant to the east foot of Wolf Creek Mountain and thence over the mountain by means of an incline railroad to First Ford station where they were transferred to standard freight cars for shipment.

BLAND COUNTY.

RUSH BRANCH PROSPECT.

A prospect that was not visited by the writers is on a low sandstone ridge half a mile south of the Stange mine and south of Rush Branch. In 1917 B. T. Johnson, of Narrows, picked up fragments of manganese ore on the surface and mined ore by means of shallow pits. In this way he obtained two carloads of ore which he shipped. He later abandoned this prospect when he began work on the crest of Flat Top Mountain at the present site of the Stange mine.

DISMAL CREEK PROSPECT.

The Dismal Creek prospect is on the east edge of Bland County three-fourths of a mile northeast of the confluence of Dismal Creek with Kimberling Creek and 3 miles northeast of Mechanicsburg. (See fig. 21.)

It consists of several openings on and near the crest of a hill which is just south-southwest of a waterfall 10 to 12 feet high on Dismal Creek and which rises 100 feet above the base of the falls. The hill is on an inner bend of the creek, being encircled by it on the northeast, east, and south sides.

The openings which were made a few years ago by E. S. Suffern, of New York, are shallow and occur at different places over an area of several acres. A north-south trench 40 feet long is on the north hillslope. The north (lower) end of it was made in a soft yellow fine-grained sandstone, whose beds lie in a nearly horizontal position, whereas the south (upper) end was dug in clay. Two pits on the crest, seven pits on the west slope, and one pit in a saddle near the road west of the hill penetrated red and yellow clays. The clays overlie the above-mentioned sandstone and are apparently residual from argillaceous beds of Oriskany age. Dismal Creek falls over massive beds of hard sandstone in this formation which dips 5° W. at the falls.

Manganese oxides, consisting largely of psilomelane both black and steel-blue in color, were found in the sandstone and clay in the cut and they apparently comprise half or more by weight of the material on the dump. The steel-blue psilomelane partly fills shrinkage cracks in black psilomelane like that shown in Plate XII. The masses of ore that were observed on the dumps weigh 100 pounds or less, are generally somewhat porous, many of them contain sand, and others show a shaly structure when they are broken. Manganese oxides of the same character were found in large quantity in the clay in the pits and very numerous small particles of ore were seen on the surface at different places on the hill. The ore-bearing area apparently comprises several acres, and although the ore on the surface and from the openings probably contains too much silica to be marketable, its quality may improve with depth.

CROCKETT MINE.

The Crockett mine is on a spur on the south side of Walker Mountain, 2 miles north of Long Spur postoffice and 10 miles northwest of Pulaski. (See fig. 26.) The property was prospected 50 years or so ago by W. N. Harmon, and was then known as the Harmon patent. Later it was prospected by J. L. Crockett and Pat H. Rorer, of Bluefield, W. Va. In 1918 E. S. Suffern, of New York, leased the mineral rights on 1,000 acres from J. L. Crockett, and worked the mine until Oct. 1, 1918. Since that time the property has been sold to John Q. Dickerson, of Charleston, W. Va.

Walker Mountain is a southeast dipping monocline, composed of Clinch sandstone at the crest, Clinton sandstone and shale on the upper southeast slope, sandstone, chert, and limestone of Helderberg and possibly of Oriskany and Cayuga age, on the lower southeast slope, and black shale of Genesee age in the valley of Spur Branch. (See fig. 26.) The ore is in sandy beds between the chert and a heavy sandstone. The mine is 550 feet above Spur Branch on a bench about 2,700 feet above sea level, which is part of

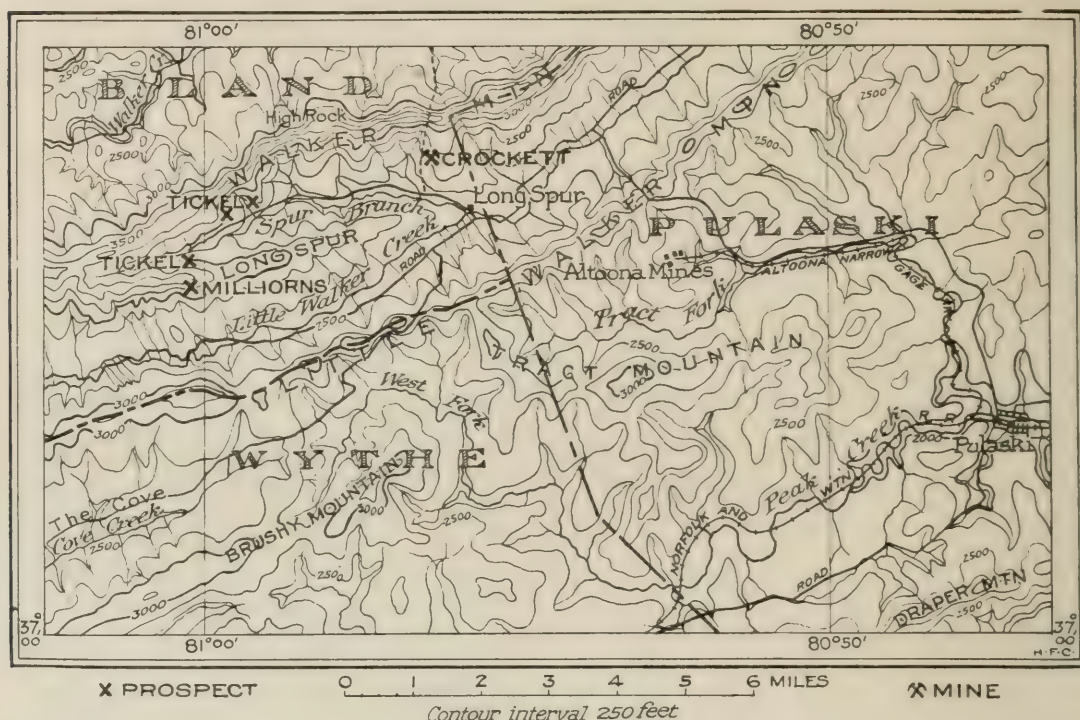


Fig. 26.—Map showing the location of the manganese mines and prospects in the southeast corner of Bland County.

the old valley-floor peneplain of a tributary of New River. Three tunnels, a shaft, and several shallow trenches and pits comprise the workings. Pits only 5 feet deep on top of the bench show little ore and do not penetrate to the bottom of the weathered zone. A shaft on the bench 35 feet deep shows some ore at 12 feet depth. A larger trench 20 feet below, which has the best showing of ore, reveals thin seams composed of crystalline and dull earthy psilomelane impregnating soft sandstone which dips gently down the southeast slope. The upper tunnel is 30 feet long and a lower one 50 feet long. Both expose yellow clay and sandy beds which carry thin ore-bearing seams 2 to 3 inches thick of highly siliceous nodular ore with turreted shapes and some crystalline ore.

The mine is reached from Long Spur by a good mountain road, but it is 15 miles by road to Pulaski, on the Norfolk & Western Railway. A carload of the best ore was shipped in September, 1918, and is reported to have run 46 per cent manganese, 5 per cent iron, and 20 per cent silica. Considerable low-grade sandy manganese ore and iron ore were still on the dump in May, 1919. The ore observed in the workings and in the dump is of too low grade to be mined profitably at that distance from the railroad.

A detailed section of the rocks associated with the ore is exposed near Long Spur postoffice, where Spur Branch cuts a small rocky gorge through the northeast plunging nose of Long Spur. The section is as follows:

Section near Long Spur postoffice.

Feet.	
	Black fissile shale, containing <i>Scizobolus</i> and other delicate thin-shelled fossils of Genesee age.
20±	Massive white chert (probably of Oriskany age).
1	Slabby sandstone containing fucoid markings.
15±	Covered.
15±	Slabby dark dense limestone and thin beds of granular fossiliferous limestone containing small quantities of galena. (Orthoceras, Ostracods, Rhyneconella, and other fossils, probably of Helderberg age.)
1	Hard laminated sandstone, weathering ferruginous and manganiferous.
15	Covered with dark brown manganiferous soil (ore zone).
25	Hard, dense, ferruginous quartzite in 2 to 3-foot beds with thin shaly partings. Mud cracks on rough bedding surfaces. Contains some white quartz pebbles. Weathers to thin beds and sandy soil. Probably equivalent to Keefer sandstone member of Clinton formation in Maryland.

TICKEL PROSPECT.

Manganese ore float with chert occurs on the G. L. Tickel place on the lower south slope of Walker Mountain, 3 miles west of Long Spur up Spur Branch. This ore is derived from outcrops of the chert and of the sandstone higher up the slope, fragments of which were brought down as wash. It is apparently not in minable quantity and has not been prospected. One-half mile farther up the valley an incline has been dug into black slate of Genesee age in the south bank of the creek. Some of it is black and shiny or slickened and resembles coal, but it contains no manganese ore and has no value.

MILLIORNS PROSPECT.

On the top of Long Spur, 4 miles southwest of Long Spur postoffice, prospects have been opened on the Buckeye Lumber Co.'s property above Lee Milliorn's farm. (See fig. 26.) Long Spur is an anticlinal ridge of

Oriskany chert, with overlying black shale of Genesee age in the valleys on both sides. The flat top of the ridge is 2,800 feet above sea level and is part of the old valley-floor peneplain. A pit 12 feet square and about 10 feet deep exposes banded variegated sand, clayey in part, which carries a little sandy manganese ore, beneath a thick bed of white chert. Five smaller pits are scattered over the top. About 5 tons of very sandy ore had been collected, but none had been shipped.

Similar ore is reported on Buck Knob on Long Spur, southwest of Milliorns, and on Joe King's property, also on top of the ridge 3 miles to the northeast. None of these deposits appear to be of value.

WILLIAMS PROSPECT.

The Williams prospect is on the south slope of East River Mountain 2 miles north of Round Bottom station and $5\frac{1}{2}$ miles by wagon road east-northeast of the mouth of Dry Fork which drains the valley south of this mountain. (See fig. 27.) Work was done at this locality in August, 1917, by S. W. Williams, sr., and S. W. Williams, jr. The only manganese ore that was marketed consisted of about one wheelbarrow full which was put in the carload of ore from the Bristol Adams prospect.

The prospect, which consists of a few pits and cuts, is on a saddle that connects a foothill with the main East River Mountain to the north. The saddle is about 2,880 feet above sea level or 560 feet above Dry Fork, and the foothill which is one-eighth of a mile or less to the south, rises less than 50 feet above the saddle. A 15-foot ledge of cliff-making, buff-colored sandstone crops out on and near the crest of the foothill and dips 29° S. This ledge is probably the basal bed of the Oriskany formation. The clays that have been penetrated by the openings have probably been derived from underlying rocks of Cayuga age.

Red and yellow ochre-colored clays were penetrated by a pit in the saddle, and a sandy yellow clay was penetrated by three shallow cuts at an elevation of 2,740 feet above sea level on the mountain slope southwest of the pit in the saddle. Manganese oxide free from quartz sand was found in very small quantity in the pit and two of the cuts, and fragments of such oxide containing much quartz sand were found in the other cut. Some of the fragments are nodular and display botryoidal surfaces. The quantity of the manganese oxide observed on the dumps at the time of visit (Aug. 15, 1918) was not sufficient to encourage further prospecting.



Fig. 27.—Map of parts of Bland and Tazewell counties, showing the location of manganese mines and prospects near Bluefield, W. Va.

BRISTOL ADAMS PROSPECT.

The Bristol Adams prospect is on the south slope of East River Mountain, 2 miles north-northwest of Round Bottom station on the New River, Holston & Western Railroad, and 6 miles by wagon road from Rocky Gap station. It is three-fourths of a mile north of Dry Fork and occurs at an elevation of 2,700 feet above sea level or 500 feet above Dry Fork. Work at this locality was done in 1917 and one carload of manganese ore which is reported to have contained between 38 and 40 per cent of manganese was shipped from Rocky Gap to Harrisburg, Pa.

The prospect, like the others along East River Mountain, has been made in a saddle that connects a foothill with the main mountain to the north. It consists of 3 or 4 small cuts that have been made mostly in red clay but partly in sandstone. The sandstone and the argillaceous beds from which the clay has been derived are probably of Cayuga age. The manganese ore consists of more or less porous psilomelane and occurs both in the sandstone and clay. The ore in the sandstone contains much sand, whereas that in the clay is free from sand. Masses of ore that were observed on the dumps show branching coral-like shapes and botryoidal surfaces. The marketed ore was hand-picked from the inclosing clay and was not washed. Considerable wash ore in small particles in the clay is present on the dumps, but the quantity of it is probably too small to be recovered at a profit. The ore deposit is said to have continued below the bottoms of the cuts but the cost of extending the cuts to a greater depth or of underground mining is said to have prevented further work.

BUCKHORN PROSPECT.

The Buckhorn prospect, also known as Prospect No. 1, is about 2 miles northeast of Round Bottom station and is on a divide between Pond Mountain to the north and Buckhorn Mountain (sometimes called Chestnut Ridge) to the south. (See fig. 27.) These mountains are parallel and trend east-northeast. The narrow valley that is between them and that heads west of the above-mentioned divide is drained by Mill Branch, a small perennial stream. This divide is about 1,400 feet above Wolf Creek which runs along the south base of Buckhorn Mountain.

The prospect at the time of visit (Aug. 23, 1918) was reached by means of trails, there being no wagon road to it. It is on the property of the Buckhorn Lumber Co., of Pearisburg and Radford, Va. Several shafts, pits, and cuts were made by C. L. King, of Pearisburg, for the

company in 1918 over an area of about 2 acres. The largest of these is an east-west cut 100 feet long and several feet deep, and a shaft 30 feet deep.

The openings penetrated red and yellow clays and sandy clays and soft sandstone which were derived from the weathering of rocks of Cayuga age. Heavy sandstone ledges of this formation are exposed on Pond Mountain to the north and on Buckhorn Mountain a short distance to the south; and although the amount and direction of the dip of the beds could not be determined, the divide appears from the distribution of the rocks of Cayuga age and from the presence of a few fragments of chert of Oriskany age on the surface to be in a shallow syncline which trends east-northeast.

Many small fragments and boulders of hard manganese oxide occur on the surface over an area of about 2 acres, and the openings which were made in this area revealed such masses in the sandstone and clay. Practically all of the masses contain much sand and analyses of them would doubtless show them to contain 20 per cent or more of silica. The clay at places, however, contains platy botryoidal masses of manganese oxide that are free from sand; the composition of these is represented by the following analysis which was furnished by J. B. Pulliam, of Round Bottom:

Analysis of manganese ore from the Buckhorn prospect.

[R. P. Sims, analyst.]

Manganese dioxide (MnO_2)	87.48
Iron oxide	5.16
Silicon	7.23
Phosphorus	.12
Manganese (Mn)	55.30

POND MOUNTAIN PROSPECT.

The Pond Mountain prospect, also known as Prospect No. 2, is on the crest of Pond Mountain about $1\frac{1}{2}$ miles north-northeast of Round Bottom station. The crest of the mountain at this locality is about 1,300 feet above Wolf Creek to the south.

The prospect is on the property of the Buckhorn Lumber Co., which recently made several shallow pits within an area of about 2 acres on the crest and north slope of the mountain. The pits penetrated weathered friable buff-colored sandstone and red and yellow clays. The unweathered rocks beneath the surface, from which the friable sandstone and the clays have been derived, are probably of Cayuga age. Rock exposures in the vicinity seem to indicate that the rocks dip at a very high angle to the north.

Fragments of psilomelane occur on the surface over an area of more than 2 acres and thin veins and pockets of it were found in the clay and sandstone in the pits, but the quantity of it thus found in the pits was small in comparison with the quantity that is on the surface. This indicates that there has been a surface concentration of the fragments due to the removal by erosion of the lighter materials, such as clay and sand. Freshly fractured surfaces of some of the psilomelane show bright iridescent colors. The inclusion of irregular areas of sandy clay and sand in the psilomelane indicates that this mineral has replaced these materials, but the replacement has not been complete so that practically all of the psilomelane contains a high percentage of silica. An analysis supplied by J. B. Pulliam, of Round Bottom, shows it to contain 49.5 per cent of manganese and 22 per cent of silica.

HIGH ROCK.

High Rock is a large projecting ledge of sandstone on the north slope and near the crest of Pond Mountain near the junction of this mountain with Buckhorn Mountain to the south, and is 1 mile north of Round Bottom station. It is several feet wide and 40 feet high and a smaller though similar ledge is just north of it. The ledges strike N. 70° E., and appear to dip north at a very high angle. They are composed of friable, coarse-grained, gray, and cross-bedded sandstone which is apparently a part of the Oriskany formation. Films of manganese oxide coat the surface of parts of the sandstone and veinlets of it penetrate parts of the sandstone but the quantity of it is apparently far too small to justify prospecting for manganese ore.

J. B. SMITH PROSPECT.

The J. B. Smith prospect, which is on property owned by J. B. Smith, is at the south base of Buckhorn Mountain and is just north of the New River, Holston & Western Railroad, one-fourth mile east of Round Bottom station. A few very small pits have been made here at various times by different parties, including H. A. Kinch, B. H. Cooper, and A. H. Stowe, but manganese ore in commercial quantity had not been discovered at the time of visit (Aug. 16, 1918).

The prospecting had been done in a recent landslide of surficial material which is composed of clay, sand, and fragments and boulders of gray quartzite. The only observed rock exposures in the vicinity are at the west edge of the landslide and at an elevation of about 70 feet above the rail-

road. These exposures reveal red shale, which is probably a part of the Clinton formation, and also reveal heavy ledges of white quartzite, which is probably a part of the Clinch sandstone. These rocks dip 45° SE., and thus underlie the landslide.

Crystalline manganese oxide, either pyrolusite or manganite, has been found as small loose fragments in the surficial material and as thin veins in some of the quartzite boulders. Probably not more than 100 pounds of these oxides was observed on the dumps and in the pits at the time of visit.

ROUND BOTTOM MINE.

The Round Bottom mine is on the Allen place in the valley of Wolf Creek 1 mile west of Round Bottom station. (See fig. 27.) It is near the top and on the east slope of a hill rising between 200 and 250 feet above Wolf Creek which flows along the south base of the hill. The hill is the lower end of a high spur of Buckhorn Mountain. (See fig. 28.)



Fig. 28.—Sketch map of the vicinity of the Round Bottom mine, showing the distribution of the rocks and the occurrence of the deposit of manganese ore.

Work was begun at this locality in August, 1917, by W. J. Rose, of Rocky Gap, who reports that he mined 35 tons of manganese ore, though the ore was not shipped by him. He was succeeded by H. A. Kinch, of New York, but at the time of visit (August, 1918) work was being done by the Elco Manganese Corporation, under the direction of Wm. B. Crawford and J. L. Ellis, of Bluefield, W. Va., which had leased the mine. This company had shipped one carload of ore before that time and was then beginning the construction of a small log washing plant on the right bank of Wolf Creek about 1,000 feet southwest of the mine. Since then the plant was completed and was operated for a short time during which a few tons of concentrates were obtained.

The hill on which the mine occurs is about 100 feet higher than the near-by hills which are remnants of old valley terraces. The rocks are concealed at most places by clay and fragments of sandstone and chert, though there are good rock exposures on the southwest slope of the hill. The distribution of the rock formations, as it is inferred from these rock exposures, and also the location of the ore body, are shown in figure 28. The ore body, as thus shown, occurs just southeast of two faults and in an area that is underlain by the Knox dolomite, though the workings themselves have been dug in residual clays that conceal the unaltered dolomite. These faults, both of which are thrust faults with the overthrust from the southeast, apparently unite at the mine, so that farther northeast the Knox dolomite rests upon the Oriskany formation. South of the mine the southernmost fault has brought the Knox into contact with the Clinch sandstone and Clinton formation. The Knox, therefore, rests upon these different beds at different places. The northernmost fault has apparently brought the Clinch sandstone into contact with the Oriskany formation. In a ravine northwest of the mine shaly fossiliferous limestone of Cayuga and Helderberg age dip 15° to 23° SE., which are overlain by thin-bedded buff sandstone containing Ostracods, and this in turn by fossiliferous coarse sandstone of Oriskany age.

The workings consist of several pits and cuts as much as 24 feet deep, that have been made within an area 250 feet square. Red, yellow, and brown clays are penetrated by the workings but the clays are in places overlain by a layer of gravel less than a foot thick and this in turn by a shallow, red surficial loam. Masses of manganese ore have been found here and there in the clays and the parts of the clays where they are present are called pockets. Several pockets had been found before the time of visit, and, although they vary from a few inches to 4 feet in their horizontal

dimensions, the depth to which they extend had not been determined. Washing tests are said to show that the ore-bearing clays will yield concentrates in the ratio of 1 part of concentrates to 2 parts of ore-bearing clay. The masses vary in weight from a fraction of a pound to 40 pounds. Many of them are compact and nodular and display botryoidal surfaces but some of them are porous and contain considerable clay. A comparatively small number of the masses contain numerous grains of quartz sand. The manganese minerals are psilomelane, manganite, and pyrolusite, with psilomelane in greatest abundance.

The carload of ore that was shipped by the Elco Manganese Corporation contained 18 tons of concentrates that had been washed by hand in a small stream just west of Round Bottom station. It was shipped in May, 1918, to John B. Guernsey & Co., Graham, Virginia. Its composition is represented by the following analysis:

Analysis of manganese ore from the Round Bottom mine.

Manganese (Mn)	34.50
Iron (Fe)	2.68
Phosphorus (P)	.021
Silica (SiO ₂)	16.46
Moisture	4.20

Several pits were observed on the slopes of a terrace-like hill that is southeast of the mine and others were being dug at the time of visit, but manganese ore in commercial quantity had not been discovered in them before that time. The pits were dug in residual clays which overlie the Knox dolomite but some of them passed through surface wash.

R. R. NELSON PROSPECT.

The R. R. Nelson prospect is on the R. R. Nelson place $1\frac{3}{4}$ miles west of Round Bottom station and $1\frac{1}{2}$ miles northeast of Rocky Gap station. It consists of an L-shaped pit 25 feet long in its longest dimension and 10 feet deep, and two or three very small pits, all of which were made in 1917 by W. J. Rose. Only the larger pit was visited; it is on the south slope of a hill at an elevation of about 400 feet above Wolf Creek. It was made in a yellow sandy clay which is apparently residual from rocks of Cayuga age. The distribution of chert of Oriskany age south of the pit and lower on the hillslope suggests that this chert and the underlying formation of Cayuga age dip at high angles to the south. A red loamy soil overlies the clay in the vicinity of the pits and it is redder there than it is elsewhere.

The largest pit had partly caved at the time of visit (Aug. 22, 1918), and the only visible manganese minerals were confined to a zone of clay a foot or less in width. The minerals in this zone and on the dump included porous masses of psilomelane and manganite, varying in size from a small fraction of an inch in diameter to those more than 1 inch in diameter, and not more than a few hundred pounds of them were observed on the dumps. No ore was shipped from the locality.

HONAKER PROSPECT.

The Honaker prospect is in the gap of Buckhorn Mountain half a mile northwest of the village and station of Rocky Gap, which is on the New River, Holston & Western Railroad. (See fig. 27.) Some prospecting has been done recently at the base of a bluff at the edge of the wagon road on the east side of the creek. A few veins and irregular masses of a soft oxide of manganese were found in a 7-foot bed of yellow friable sandstone in which there is some chert. The thickest vein of manganese oxide is 3 inches wide and the largest irregular mass is 6 inches thick. This sandstone bed dips 25° NW. and is overlain by a 12-inch layer of green sandy shale that contains grains of greensand and nodules of chert and phosphate, which is in turn overlain by a bed of massive chert 50 feet or more thick. (See Pl. VI.) The manganese-bearing sandstone is underlain by friable sandstone, parts of which are stained by manganese oxide. All these rocks are part of the Oriskany formation. A section of them is given on page 36.

ANGEL PROSPECT.

On the road over East River Mountain from Bluefield to Rocky Gap there is a bench on the mountain side at about 2,700 feet altitude made by the outcrop of Oriskany sandstone, which dips 25° SE. into Laurel Creek valley. (See fig. 27.) This bench affords a favorable place for the accumulation of ore. Float ore is said to be plentiful on the surface of the bench on a 7,000-acre tract owned by R. B. Angel and J. C. Stone, of Roanoke, and known as the Angel tract of the Hardwood Lumber Co. R. B. Miller, of Bluefield, began prospecting the property by digging 2 pits near the road. The larger opening, which is above the road at an altitude of 2,650 feet, is a trench 60 feet long in the side of a spur. The face of the cut, 10 feet high, exposes soft sandstone which is replaced along joints by sandy manganese ore. A lower pit at the road, 20 feet by 20 feet and 15 feet deep, exposes similar material. The ore zone is about 75 feet below a 30-foot bed of chert of Oriskany age, which underlies the black shale of

Genesee age, both of which are exposed on the road below the pits. Much of the ore seen in the dump consisted of soft sandstone fragments cemented by sandy psilomelane. About half a carload of very sandy manganese ore was said to have been mined and hauled to Rocky Gap and shipped with ore from the Suiter mine.

STARLING PROSPECT.

The Starling prospect, which is on land owned by B. F. Starling, is on the south slope of East River Mountain $3\frac{1}{2}$ miles west-northwest of Rocky Gap, Va., and 3 miles east-southeast of Bluefield, W. Va. It is in a field in a saddle, 2,760 feet above sea level, that lies between a foothill and the main mountain to the north. Mr. Cole dug 3 small pits in 1917; one of these, according to Mr. Starling, was 10 feet deep, and another 6 feet deep. They had, however, been filled up before the time of visit (Aug. 14, 1918). Mr. Starling stated that a white sand was struck after the surficial material was passed through and that no manganese ore was found in the sand. Although no ore had been shipped away from the locality before the time of visit, only a few fragments of manganese oxide were found on the surface at that time, and these contained too much quartz sand to be marketable.

No rock exposures were observed in the vicinity but the character of the rock debris here and also farther south on the slope of the mountain indicates that rocks of Cayuga age are probably the surface formation in the saddle where the prospect occurs. These rocks, together with the underlying and overlying rock formations, probably dip to the south, just as they do at other localities on East River Mountain where dips have been observed.

AKER PROSPECT.

The Aker prospect is on the M. D. Aker place on the south slope of East River Mountain 4 miles west-northwest of Rocky Gap, Va., and 3 miles east-southeast of Bluefield, W. Va. Several small pits were made recently by W. J. Rose, of Rocky Gap, at an elevation of about 2,600 feet above sea level on and near a saddle that connects a foothill with the main mountain to the north. They penetrate surficial material that consists of clay, sandy clay, sand, and brecciated sandstone which have probably been derived from rocks of Cayuga age. Fragments of psilomelane weighing as much as 25 pounds each were obtained from the pits and from the surface over an area of $1\frac{1}{2}$ acres. Mr. Rose says that not more than a wheelbarrow full of lump ore was found but that there was a large quantity

of wash ore. Much of the psilomelane contains considerable sand. An analysis furnished by Mr. Rose showed the presence of 26 per cent of manganese and more than 20 per cent of silica in a sample that was collected by him.

LAMBERT PLACE.

Sam Lambert did a small amount of prospecting on his place, which is on the south slope of East River Mountain 3 miles west of the Starling place and 2 miles south of Bluefield, W. Va. No manganese ore has been marketed from this place.

GUY PLACE.

Manganese ore is reported to occur on the Will Guy place on the north slope of Buckhorn Mountain about 3½ miles south of Bluefield, W. Va., but very little or no prospecting has been done.

BISHOP PLACE.

The Bishop place, which is on the south slope of Buckhorn Mountain 6 miles west of Rocky Gap, was prospected for manganese ore in 1917 by W. J. Rose, of Rocky Gap. This place was not visited by the writers but Mr. Rose stated that 7 or 8 tons of ore which was too siliceous to be salable were taken out.

BIG RIDGE PROSPECT.

The Big Ridge prospect is on land owned by R. B. Miller on the flat top of Big Ridge 3,840 feet above sea level, 2½ miles south of Graham, Va. (See fig. 27.) Numerous small fragments of manganese oxide in which there are many quartz grains are on the surface at this locality. These led Mr. Miller to dig several pits with the hope of discovering a commercial quantity of salable ore. The pits pass through sandy surficial material into sandstone of Clinton or Cayuga age. Some manganese oxide was found in the walls of the pits but not in the sandstone at the bottom. The oxide has partially replaced the sandstone and the ore is thus very sandy and the loose fragments which were once embedded in the sandstone are now found on the surface.

Several shallow pits which show similar ore were reported by Mr. Miller to have been dug at places along the crest of Big Ridge for a distance of 1½ miles northeast and southwest of the above-described openings along the crest of the ridge. These were not visited by the writers.

EAST RIVER MOUNTAIN PROSPECTS.

On the southeast slope of East River Mountain south of Bluefield, chiefly on the bench or line of foothill knobs composed of sandstone of Oriskany age, there are several prospects for manganese ore. On the road from Bluefield into Nye Cove, 3 miles south of Graham, at an altitude of about 3,000 feet near the head of the cove, soft disintegrated sandstone of Oriskany age exposed in the road contains thin seams of manganese oxides filling crevices, and the rock is stained by wad. Search was made for ore in massive ledges of white sandstone, presumably of Oriskany age, at an elevation of 3,500 feet near the saddle through which the road passes over the mountain. Here a pit 20 feet by 30 feet and 10 feet deep exposes sandstone stained by manganese. If ore was obtained, no evidence now shows on the ground. Other prospects on the southeast slope of the mountain are described under appropriate headings.

WALKER PLACE.

H. F. Walker, of Hicksville, reported the occurrence of manganese ore on his place on the south slope of Rich Mountain $1\frac{1}{2}$ miles north-northwest of Hicksville station. He stated that the quantity of ore is less than that at the "Gum Mast," on the south slope of Rich Mountain, described on page 158. He has made a few small openings but none of them were visited.

LEAS-McVITTY TRACT.

A timber tract of 48,000 acres owned by Leas & McVitty, Inc., of Philadelphia, Pa., is reported to contain several occurrences of manganese ore. The occurrences have been examined by representatives of steel companies with the object of leasing parts of the property that might contain deposits of commercial importance but no parts of the property had been leased by such companies before August, 1918, and no prospecting of consequence had been done before then. Some of the occurrences, a few of which were visited by the writers, are here mentioned.

The Wolf Creek or Donahue prospect (see fig. 27), described on page 169, is claimed by Leas & McVitty to be on their property, but at the time of visit (Aug. 12, 1918) there was litigation over the location of the property line and thus over the ownership of the prospect.

Small fragments of sandy manganese oxide occur on the surface on the crest of Round Mountain just east of the Suiter mine, which is $1\frac{1}{2}$ miles northwest of the village of Suiter. (See Pl. XXVIII and fig. 27.) The area in which they occur is small and a few shallow pits were made at

this and at other places. Most of the pits revealed no ore; the others revealed a small quantity of iron oxide and sandy manganese oxide. The deposit at this locality is the east edge of the deposit at the Suiter mine, but is probably of no commercial importance. The boundary between the Leas-McVitty tract and the Mann-Crockett tract, on which the Suiter mine is located, trends S. 30° E., just east of the workings of the Suiter mine.

Small fragments of manganese oxide in which there are many grains of quartz sand were observed in the trail that follows the crest of Round Mountain, beginning at a locality three-fourths of a mile west of the forest ranger's tower and extending westward for two-tenths of a mile. A shallow pit had been dug in red clay a few feet east of the crossing of this and another trail, and it appears to have yielded no fragments of manganese oxide for none were observed on the dump. This part of the mountain is capped by sandstone of Cayuga or Oriskany age, though no ledges were observed in the vicinity of the occurrence of the fragments of manganese oxide.

Fragments of manganese ore, according to A. W. Suiter, the field representative of Leas & McVitty, occur on Garden Mountain at a locality about 2 miles northwest of Suiter station. Mr. Suiter says that the fragments thus occurring on the surface would no more than fill a bushel measure. No prospecting has been done here.

Manganese ore is reported to occur on Round Mountain near Bastian station on the New River, Holston & Western Railroad, but no prospecting has been done.

Fragments of hard steel-blue psilomelane occur on the surface over an area of less than 1 acre at the "Gum Mast," which is on the south slope of Rich Mountain 1½ miles northwest of Hicksville station on the New River, Holston & Western Railroad and 1 mile east of the Four-Foot Trail that crosses Rich Mountain. The occurrence of manganese ore is on a trail and on a small hill, 2,925 feet above sea level that lies between a foothill and the main mountain to the north. The psilomelane is mostly free from quartz sand and fragments of sandstone. It would, therefore, make a good grade of ore but the quantity of it is small, there being not more than 200 or 300 pounds of it on the surface. Boulders of gray and buff-colored sandstone that occur on the surface are near the place and are apparently of Cayuga age. The dip of the rocks, as shown by exposures farther east, is to the south.

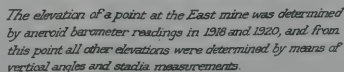
ON THE CREST OF ROUND MTN., BLAND COUNTY

From planetable survey by H.D. Miser

July 1920

EXPLANATION

- γ^{12°
- Strike and dip of rock strata



SUITER MINE.

Location.—The Suiter mine, which comprises two separate groups of workings known as the East mine and the West mine, is $11\frac{1}{2}$ miles northwest of the village of Suiter, the terminus of the New River, Holston & Western Railroad, and is 10 miles almost due south of Bluefield, W. Va. (See fig. 27.) It is in a low saddle near the west end of Round Mountain, a northeastward-trending ridge with numerous transverse spurs, and is near the junction of this mountain with Garden Mountain to the southwest. The East mine, which is the main working, is near a trail that crosses the mountain from the former site of Grapefield postoffice in Wolf Creek Valley to Suiter, in Hunting Camp Creek Valley; and the West mine, which is also on the crest of the mountain, is 1,800 feet southwest of the East mine. (See Plate XXVIII.) The marketed manganese ore was hauled by wagons over a rough road down the south slope of the mountain to Suiter whence it was shipped. The descent from the mines to Suiter is about 1,000 feet, the mines being 3,350 feet and Suiter about 2,350 feet above sea level. The top of the mountain may be a remnant of the old summit peneplain.

History and production.—Although fragments of manganese ore occur on the surface at places along trails and wagon roads on Round Mountain the identification of the ore and the discovery that it was of commercial importance did not take place until early in 1917. The discovery was made by R. B. Miller, of Bluefield, W. Va., who later purchased from J. P. Meek, of Burkes Garden, the mineral and agricultural rights of the 136-acre tract on which the mine was opened. Mining was begun by Mr. Miller in May, 1917, and was discontinued in September, 1918. Since then the mine has remained idle and has been sold to I. T. Mann and John L. Crockett, of Bluefield. The production of the East mine has been about 6,000 tons of manganese ore and that of the West mine about 3 or 4 carloads.

Geology.—The ore deposits are in interbedded sands and clays and in overlying sandy surficial wash that is about 5 feet thick. The sands have been derived by weathering from beds of hard sandstone and the clays have been derived from beds of calcareous shale or earthy limestone. The rocks from which they have been derived are of Cayuga or Oriskany age.

The ore-bearing beds are much fractured and where they show bedding they lie nearly flat, whereas the rocks that are exposed on the north slope of the mountain dip north and those on the south slope dip south, the dips

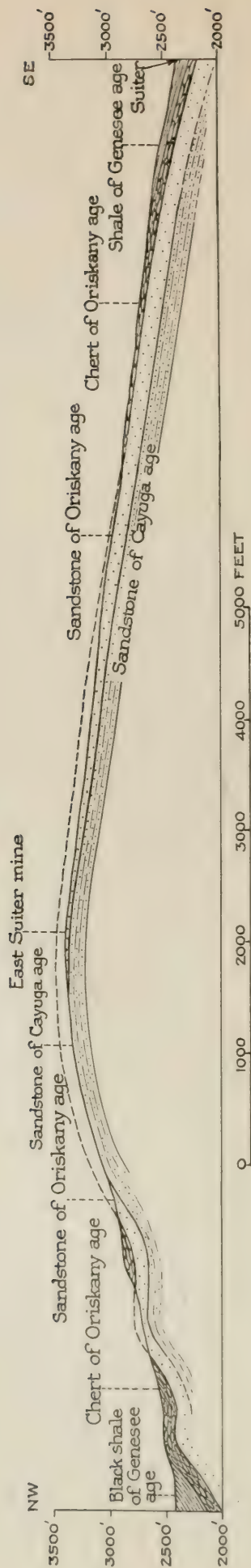


Fig. 29.—Sketch section through Round Mountain extending south-southeast to Suiter, Bland County.

toward the valleys being as much as 25° . In going down the mountain slopes, outcrops of the Oriskany formation and of the overlying shale of Genesee age are met in the order named overlying the sandstone of Cayuga age. The mines are therefore on the crest of an anticline. (See figure 29.) The axis of the anticline roughly follows the crest of Round Mountain. East of the mine the anticline widens and is more deeply eroded so that between the mine and Hicksville the Clinton formation, which underlies the rocks of Cayuga age, is exposed. Just west of Hicksville the anticline plunges eastward so that outcrops of the shale of Genesee age and higher beds encircle the east end of the mountain. Southwest of the mine the anticline widens and several rock formations that are older than the Clinton are exposed in Burkes Garden and on the mountains that encircle it.

Manganese ore deposits of the East mine.—Manganese ore in commercial quantity has been found in surficial wash and on the surface over an area of 2 or 3 acres at and just south of the mine, though the ore-bearing wash occurs over an area of altogether 10 acres or more. The wash is a thin red sandy loam, at no place over 5 feet in thickness. The masses of ore in it vary in size from fine particles to those weighing several pounds or more. Many of the larger masses picked up were found on the surface but some were plowed up in a small field. Such ore was shipped without being washed and it in fact made up the first few carloads to be shipped. The ore for the first two carloads, which included some ore that was picked up from the surface at the West mine, contained 46.7 per cent of manganese. The manganese content of these first two carloads has exceeded that of practically all of the subsequent shipments from the East mine. Some of the surficial material has been washed in a washing plant to recover the smaller particles of ore, though most of it did not contain enough ore to justify washing, and some of it that was washed contained too much silica in the form of sandstone fragments and quartz grains to be marketable.

The greater part of the marketed ore has been obtained from the sand and clay, much of which is sandy, that underlie the surficial wash. These are buff, yellow, and red in color and are interbedded. The greater part of the ore occurs in the sandy clay. A very small quantity of chert with fine concentric banding was observed in the clay.

Manganese minerals have been found at numerous places in the workings, which are open cuts 20 feet deep in places, but workable quantities of ore are confined to large, though by no means solid, ore bodies which are called pockets. The largest ore body that had been worked prior to the

time of first visit (August, 1918) was in the main cut, which is irregular in shape and 20 feet or more deep at the deepest place. (See Plate XXIX.) This yielded the greater part of the production of 6,000 tons that had been shipped from the mine before that time. It had been mostly mined out at that time and work was being confined to two small adjoining pockets. A section of a pillar standing in the middle of the main cut in August, 1918, was as follows:

Feet.

- 6 Buff dry barren clay.
 - 1 Manganese ore in banded yellow clay. Good-grade hard psilomelane and some soft pyrolusite.
 - 1 Yellow dry clay banded with black manganiferous clay.
 - 1 Yellow and white sand, somewhat stained by manganese oxide.
 - 4 Buff sand of white quartz grains, replaced in part by manganese ore in pockets.
 - 3 Yellow clay streaked with red, containing considerable good-grade psilomelane in pockets.
- Floor of hard yellow clay streaked with red containing psilomelane and manganite.

A few pits 20 feet or less deep have been sunk in the vicinity of the deeper cuts but they had failed to show minable quantities of ore. The trench that extends northwest from the main cut is 150 feet long, 7 feet wide, and 10 feet deep at the deepest place. It reveals ochre-colored clay in the bottom and interbedded clay and sand in the sides, in addition to about 2 feet of red sandy surficial wash. The only manganese ore that was found in the trench was in the wash. Considerable ore like that from the main cut was removed from the south cut down to a depth of 15 feet.

Prospecting was being done by means of a hand drill at the time of the first visit, in August, 1918, and it was planned to continue the prospecting by this method so as to determine the size of the known ore bodies or to discover new ones.

At the time of the second visit (July, 1920) the sides of the cuts had fallen in and at no place was ore in minable quantity observed. If ore in such a quantity does occur here it will probably lie farther below the surface than the ore that has already been mined, and in consequence of this its recovery will require underground mining or the stripping of much barren material.

The minerals that have been found at the East mine include psilomelane, pyrolusite, wad, and brown iron oxide, all of which are generally intimately mixed, though the iron oxide is largely confined to an area of



(A) Main cut of East Suiter mine, Bland County, in August, 1918.



(B) The West Suiter mine, Bland County, in August, 1918.

1,000 square feet or less just west of the south end of the main cut. Psilomelane and wad are the most abundant minerals at and near the surface whereas psilomelane and pyrolusite are the most abundant in the deeper parts of the workings. Some of the psilomelane has botryoidal surfaces. The pyrolusite lines cavities in the psilomelane, is disseminated through it or occurs as radiating fibers in concentric layers in it. The wad is a dark-brown mineral with a low specific gravity and some of it is presumably an alteration product of pyrolusite or is changing into that mineral, for it shows a radiating fibrous structure that is so commonly characteristic of pyrolusite at this and other localities. A partial analysis of wad with such a structure is given on page 48. Some of the wad, like the pyrolusite, occurs as concentric layers in the psilomelane, similar to that shown in Plate XV.

The ore has partly, and in some places entirely, replaced the inclosing sand and clay, as shown by the inclusion of numerous sand grains in some of it and by the inclusion of irregular areas of clay and sand, which preserve their original bedded structure. In fact, most of the ore contains cavities that are filled with clay and sand. The ore, therefore, required crushing and washing to remove as much of these materials as possible. Still the percentages of silica and alumina as shown in the many accompanying analyses of carload shipments furnished by Mr. Miller were generally high. The approximate average composition of the shipments as computed from these analyses is 38.384 per cent of manganese, 8.435 of iron, .168 per cent of phosphorus, 12.885 per cent of silica, 4.226 per cent of alumina, and 15.459 per cent of moisture. Because Mr. Miller questioned the accuracy of most of the analyses of the carload shipments of his ore, the writers carefully collected an average sample from a loaded freight car and sent it to Penniman & Browne, analytical and consulting chemists of Baltimore, Md., for analysis. The sample was collected from a car at Narrows, Va., the car being on its way from Suiter, Va., to a furnace. The analysis showed the ore in the car to contain 38.61 per cent of manganese, 7.35 per cent of iron, and 15.69 per cent of silica. These percentages agree rather closely with the approximate average of the many shipments of which analyses are given below:

Analyses of washed manganese ore from the East Suiter mine.

No.	Manganese. (Mn)	Iron. (Fe)	Phosphorus. (P)	Silica. (SiO ₂)	Alumina. (Al ₂ O ₃)	Moisture.
1	39.019	.....	.....	.....	.....	16.069
2	38.399	8.825	.190	9.010	.....	11.963
3	37.826	9.300	.189	9.530	4.214	13.997
4	37.773	.....	.....	.....	.....	15.755
5	36.571	8.650	.187	12.200	4.753	13.154
6	36.740	8.350	.196	8.360	4.452	13.154
7	40.692	6.950	.199	9.320	4.390	12.961
8	38.422	8.125	.188	9.400	4.649	17.287
9	37.439	9.350	.184	10.340	3.871	16.107
10	38.717	8.025	.172	10.280	4.268	16.974
11	33.837	7.325	.154	19.890	4.142	13.117
12	38.103	.....	.....	.....	.....	15.305
13	39.197	6.175	.145	10.640	4.452	19.252
14	37.491	7.650	.145	13.020	4.201	17.675
15	37.501	8.050	.162	11.940	4.247	17.694
16	39.755	7.300	.171	8.680	4.695	13.502
17	37.127	8.050	.167	11.830	4.414	17.12
18	39.019	7.975	.170	9.420	4.118	16.069
19	39.244	7.050	.166	9.950	4.482	14.413
20	37.284	7.825	.162	11.970	4.548	18.046
21	38.33	7.525	.162	10.580	4.661	17.929
22	39.972	6.175	.155	10.480	4.548	16.076
23	39.76	6.350	.154	9.660	5.021	14.232
24	38.802	6.900	.158	10.380	5.055	15.59
25	40.839	7.575	.158	8.28	3.469	16.369
26	35.184	11.750	.207	11.380	3.389	7.18
27	42.784	6.350	.164	6.900	2.670	15.889
28	37.725	.....	.....	.....	.....	15.9
29	37.725	.....	.....	.....	.....	15.9
30	38.252	9.725	.164	10.530	4.214	16.056
31	37.958	7.275	.151	12.620	3.959	18.153
32	38.531	6.325	.150	12.340	4.996	19.922
33	35.935	7.375	.152	15.110	4.561	20.424
34	37.284	8.525	.174	11.020	4.231	14.558
35	36.323	8.300	.165	13.790	4.059	16.026
36	38.103	.....	.....	.....	.....	15.305
37	40.955	7.350	.172	8.170	3.272	13.84
38	38.103	.....	.....	.....	.....	15.305
39	41.196	7.075	.173	8.220	3.117	14.964
40	42.60	.....	.....	20.66	.....	15.2
41	42.715	.....	.....	7.93	.....	8.
42	42.31	.....	.....	11.20	.....	12.8
43	42.22	.....	.....	12.20	.....	17.2
44	41.13	.....	.....	14.32	.....	17.
45	45.37	.....	.....	7.80	.....	13.51
46	42.15	.....	.....	10.60	.....	7.
47	42.60	.....	.....	8.90	.....	7.
48	37.80	.....	.....	21.00	.....	16.
49	40.07	.....	.....	14.5	.....	19.
50	41.50	.....	.....	12.5	.....	16.6
51	43.62	.....	.....	17.72	.....	6.
52	37.07	.....	.....	18.62	.....	17.7

Analyses of pyrolusite from the Powell's Fort mine.²

No.	Manganese. (Mn)	Iron. (Fe)	Phosphorus. (P)	Silica. (SiO ₂)	Alumina. (Al ₂ O ₃)	Moisture.
53	37.07	.....	.....	18.62	.....	17.7
54	36.40	.....	.....	21.14	.....	17.6
55	34.35	.....	.....	17.20	.....	17.2
56	18.80	28.82	.....	19.36	.....	4.2
57	37.07	.....	.....	18.62	.....	17.7
58	38.70	.....	.....	15.40	.....	18.4
59	33.38	.....	.....	21.20	.....	18.3
60	37.07	.....	.....	18.62	.....	17.7
61	38.70	.....	.....	15.40	.....	18.4
62	39.75	.....	.....	9.10	.....	15.5
63	33.80	.....	.....	15.60	.....	18.2
64	39.75	.....	.....	9.10	.....	15.5
65	31.70	.....	.....	21.04	.....	19.9
66	31.70	.....	.....	21.04	.....	19.9
67	42.40	.....	.....	.....	.....	16.4
68	42.40	.....	.....	8.20	.....	16.4

1-27. Shipped during June, July, and August, 1917, to the Juniata Furnace & Foundry Co. A. S. McCreath & Son, analysts.

28-39. Shipped during July and August, 1917, to E. E. Marshall. A. S. McCreath & Son, analysts.

40-68. Shipped from August, 1917, to January, 1918, to the Seaboard Steel & Manganese Corporation.

Manganese ore deposits of the West mine.—The manganese ore at the West mine is in surficial wash and in sand and coarse friable sandstone or fine conglomerate beneath it. This coarse sandstone is believed to be the same as the coarse porous fossiliferous sandstone of Oriskany age which caps the higher parts of the mountain. The ore-bearing wash, as shown by the occurrence of masses of ore on the surface, covers an area of several acres on the gentle east slope of the mountain at and near the mine. In fact, a considerable part of the marketed ore from this mine was picked up from the surface. Ore was found in minable quantity in sand and friable sandstone through a large part of the length of a cut or trench, 150 feet long, on the crest of the mountain. (See Pls. XXVIII and XXIX.) The cut is about 40 feet wide and is said to have passed through the ore-bearing sand into underlying dark-colored clay at the deepest part of the pit, 18 feet in depth. Four masses of fairly hard gray much fractured sandstone were exposed in the cut. The sandstone between the hard masses was also much fractured and was weathered to a soft sand with which some clay is mixed. Parts of the sand are yellow but others are red. The manganese ore is largely confined to the sand. The ore consists mainly of fairly com-

compact psilomelane but partly of manganite which is disseminated through the psilomelane. A few specimens of a rod-like variety of psilomelane were found, a photograph of one of which is given on Plate X. The ore not only occupies cracks between the fragments of sandstone but has in large part replaced the fragments. The silica content of much of the ore is high, as would be expected from the presence of grains of quartz that adhere to the surface of the ore fragments and that occur in the fragments themselves. On the upper east slope of the mountain a trench 300 feet long and 10 feet deep in its deepest part, trends N. 70° E. and has been dug through the wash into underlying beds of clay and soft shaly sandstone. The wash as revealed in the trench averages about 2 feet thick. The clay and sandstone dip 13° E.-NE. and were found to contain no ore, although the trench is really an eastward continuation of the upper trench which carries the ore.

The two accompanying analyses, furnished by Mr. Miller, represent the composition of two carloads of ore that have been shipped from this mine:

Analyses of manganese ore from the West Mine.^a

[Ledoux & Co., analysts.]

	1	2
Manganese (Mn) ^b	51.39	46.13
Iron (Fe) ^b	.48	.90
Copper (Cu) ^b	.045	.04
Silver (Ag) ^b	^c	.....
Oxygen (O) ^{ba}	13.84 ^e	12.42 ^f
Moisture at 212° F.	.68	1.42

^a Sampled at Standard Tale Works.

^b Determined after drying sample at 212° F.

^c 10 ounces per ton of 2,000 pounds.

^d Available oxygen.

^e Equivalent to 75.19 per cent of MnO_2 .

^f Equivalent to 67.48 per cent of MnO_2 .

Mining and milling.—The mining was done in open cuts by means of picks, shovels, and scrapers, aided by a small amount of blasting. The prospecting was done by means of pits and trenches and hand drills, although, as previously stated, some ore was picked up on the surface. None of the ore picked up on the surface at the East mine and no ore from the West mine was treated before it was shipped, but the ore that has been mined from the cuts at the East mine was washed to free it as much as possible from sand and clay. Before Dec. 20, 1917, the ore was washed by hand in a sluice trough on Hunting Camp Creek at Suiter except during

dry seasons when the stream was low, at which times some of the crude ore was shipped to Rocky Gap, where it was washed in a similar trough on Wolf Creek. After Dec. 20, 1917, all ore was treated in a washing plant which was erected on Hunting Camp Creek at Suiter. (See Pl. XXX.) The plant was equipped with a McLanahan-Stone log washer consisting of 2 steel logs, 24 feet in length. After treatment in the washer, the ore was elevated to a picking belt, where clay balls and rock fragments were picked out. The belt conveyed the concentrates to the ore bin from which it was loaded directly into freight cars.

The ore in the bin at the time of first visit (Aug. 13, 1918) consisted almost entirely of pieces less than half an inch in diameter. The first 55 analyses given in the table on page 164 represent the composition of this number of carloads of ore treated in sluice troughs, whereas the last 13 analyses (Nos. 56-68) represent the composition of as many carloads of ore that were treated in the washing plant at Suiter.

SHOTT PROSPECT.

On the north slope of Garden Mountain about 2 miles southwest of Grapefield postoffice and 3 miles east of Crabtree Gap (see fig. 27), prospecting has been done by J. H. Shott and E. H. and W. G. Easley, of Bluefield, W. Va. The openings are near the top of a spur of Garden Mountain, 400 feet above Wolf Creek, on the property of S. S. Kidd. (See fig. 30.) The main pit, 10 feet by 15 feet and 15 feet deep, is on the upper west slope of the spur, at an altitude of 2,840 feet. It is in soft sandstone just beneath a ledge-making coarse sandstone, presumably of Oriskany age. The sandstone is somewhat folded but has a general northwest dip. A smaller pit 6 feet by 12 feet and 10 feet deep to the north down the spur is also in buff sand containing a few thin seams of siliceous psilomelane, which underlies crushed iron-impregnated coarse sandstone. The sandstone is either broken by a small fault from which a nearby big spring issues or is sharply bent into an anticline, as shown in the section in figure 30. A local syncline between these two sandstone ledges incloses overlying chert of Oriskany age. Three smaller pits in a ravine on the east side of the spur are in red soil and yellow residual clay, presumably derived from underlying calcareous beds of Cayuga age.

Most of the ore taken out of the pits was brown iron oxide of good grade, of which some of the larger masses were of radiate fibrous limonite. Only a small amount of manganese ore was obtained.

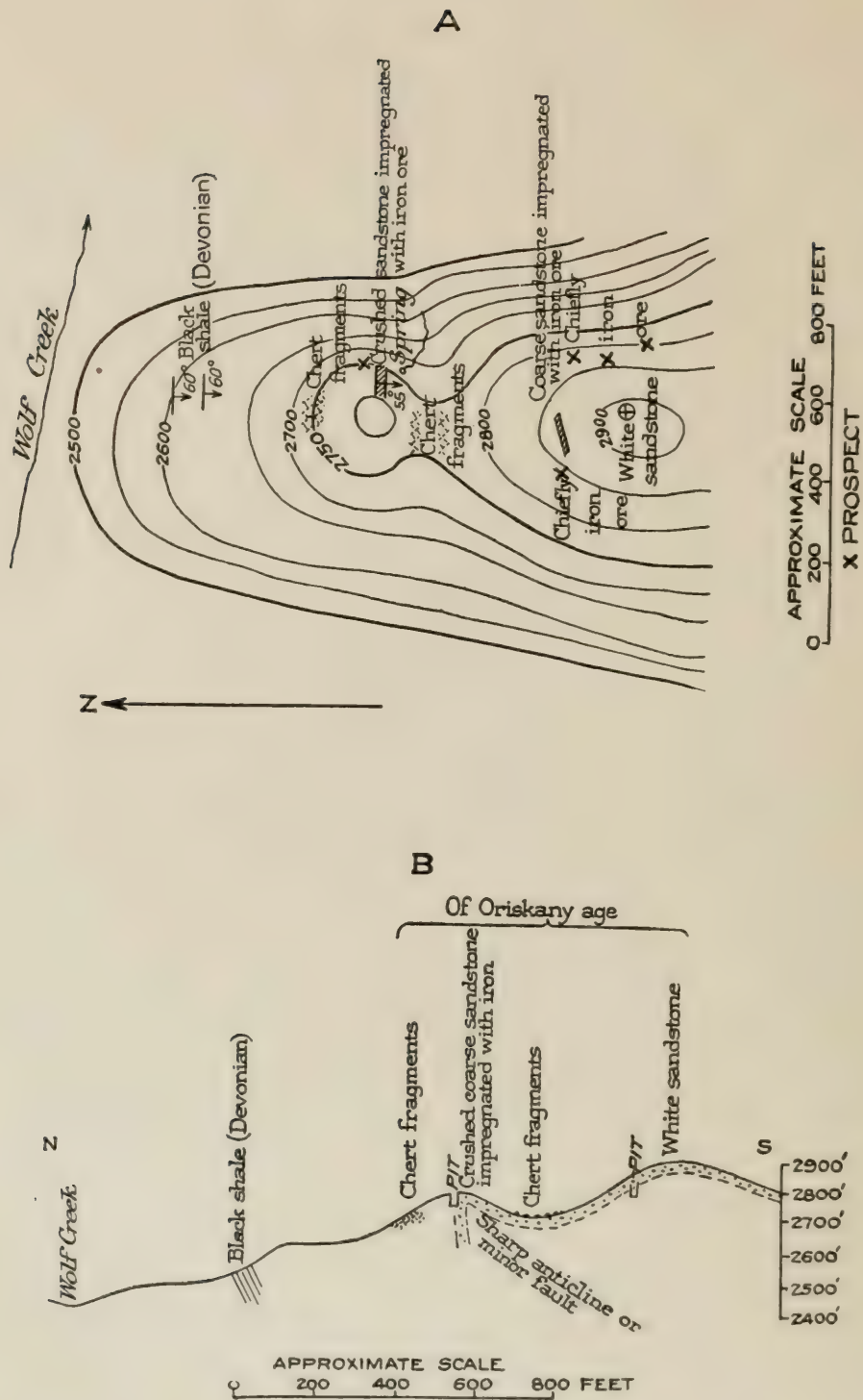


Fig. 30.—Sketch map (A) and section (B) at the Shott prospect, Bland County.

A small pit was opened by the same parties on the property of Verny Kidd north of the above prospect across Wolf Creek, just below the wagon road. The pit is on the side of a stream terrace about 70 feet above the creek, and is in clay which is capped by chert and sandstone wash from the mountain slope above. Small fragments of manganese ore, some of it crystalline manganite, are scattered through the clay and a bucket full had been collected. It is apparently in wash from the hillside, somewhat concentrated by stream action when the flood plain of the creek flowed at this level.

DONAHUE PROSPECT.

The Donahue prospect, also known as the Wolf Creek prospect, is on a knob on the south side of Rich Mountain 7 miles south of Graham and 2½ miles east of Crabtree Gap. (See fig. 27.) Work has been done here recently by Messrs. J. A. Donahue, Easley, Shott, and French, of Bluefield, W. Va., and 21 tons of manganese ore had been hauled to Bastian station on the New River, Holston & Western Railroad—a distance of 14 miles by wagon road—where it was awaiting shipment at the time of visit (Aug. 12, 1918). Work at the principal opening had, however, been discontinued at that time on account of litigation over the title of the land, as it is claimed to be on the Leas-McVitty tract.

The principal opening, which is a cut 25 feet long, 30 feet wide, and 6 feet deep at the deepest place, is on the east slope of the knob and only a few feet below the crest, which is about 2,980 feet above sea level or about 400 feet above the east-west wagon road at the south base of the knob. The crest of the knob is underlain by a coarse-grained buff-colored sandstone which at places contains small fossils (*Ostracoda*) of Cayuga age. Although no ledges were observed from which a measurement of the dip could be made, the distribution of the debris indicates that the dip is steep to the south.

The sandstone that has been penetrated by the cut is friable and has been crushed into fragments of small and large size. These fragments have been cemented together by brown and red oxides of iron and by manganese oxides, chiefly psilomelane, and have been partly replaced by them. In parts of the cut the iron and manganese oxides are intimately mixed but in others they occur separately, and at places they contain grains of quartz and are associated with clay. The manganese oxides form a considerable part of the ore-bearing rock. Parts of the psilomelane have a radiate structure, consisting of short radiating cylindrical tubes (Plate X) and some of it displays botryoidal surfaces. Many fragments that are composed mostly

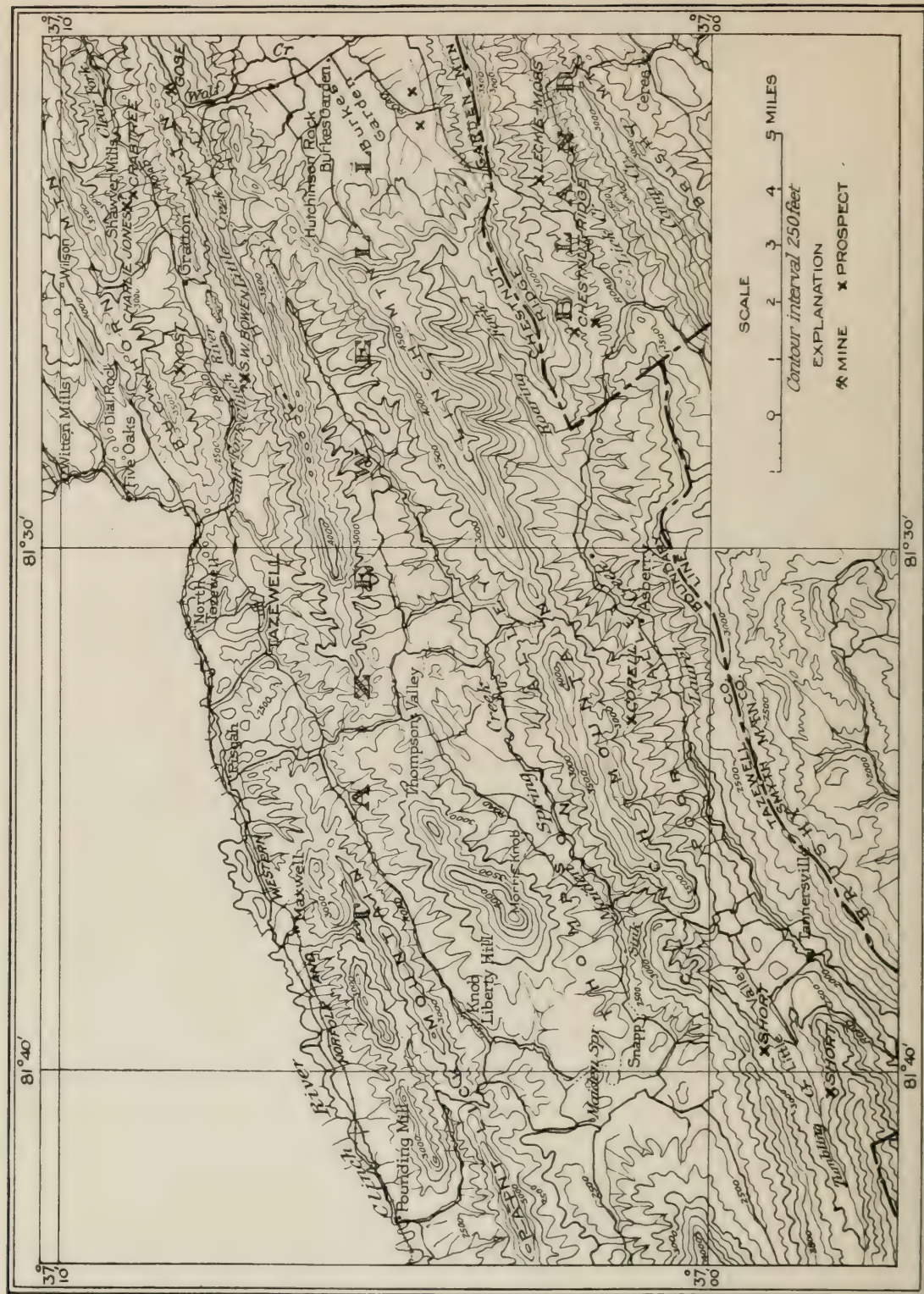
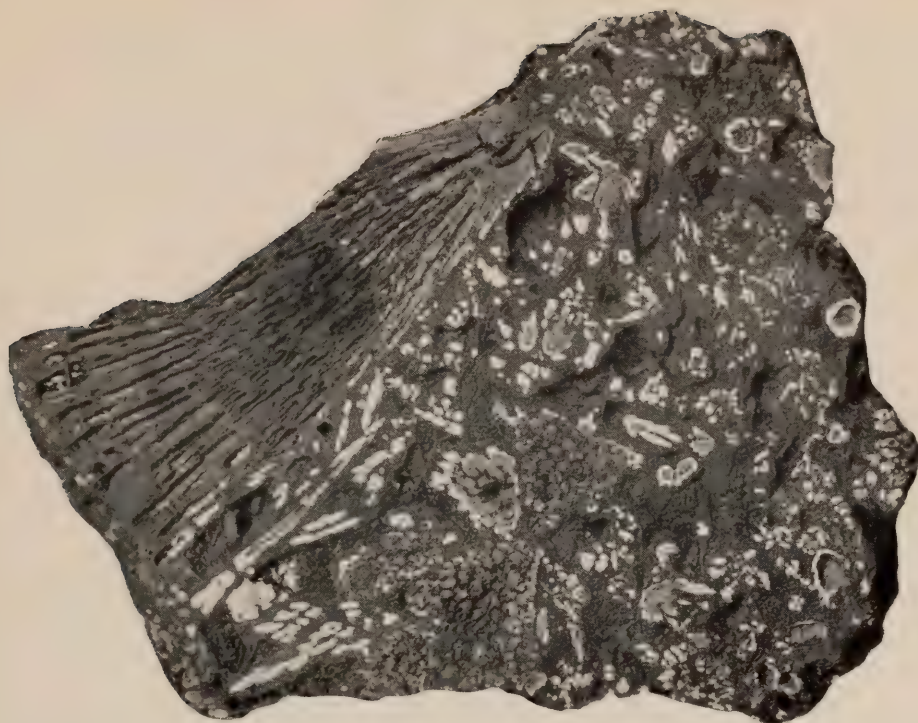


Fig. 31.—Map of southern Tazewell and western Bland counties showing the location of the manganese mines and prospects.



(A) Polished specimen showing iron oxide with a radiate tubular structure. Donahue prospect, Bland County.



(B) Washing plant of Suiter mine at Suiter, Bland County, in August, 1918.

of iron oxides but partly of manganese oxide and white and yellow clays also show a radiate structure. A peculiar feature of such fragments is that clay fills minute radiating tubes of manganese and iron oxides. (See Plate XXX.)

Another cut has been made lower on the east slope of the knob at an elevation of 2,940 feet above sea level. It was dug in red sand and clay in which there are fragments of iron and manganese oxides and fragments of sandstone containing these oxides. These fragments have apparently been derived by wash from the ore deposit that is revealed in the cut higher on the knob.

A third cut, 15 feet or more long, several feet wide, and several feet deep, in which work was being done at the time of visit, is about half a mile southwest of the main opening and is on the south slope of Rich Mountain at an elevation of 2,620 feet above sea level. It was being dug in red sand and clay in which there are fragments of coarse-grained sandstone. The writers did not see any manganese ore in the cut nor on the dump, though a box contained a few pounds of manganese oxides which were said to have been taken from the cut.

The principal deposit of manganese ore at this locality is the one on the crest of the knob, and, although its size had not been fully proved by prospecting before the time of visit, it is probably small. The ore that had been hauled to Bastian was hand-picked and was not washed, but at the time of visit it was planned to wash the next ore to be marketed, in a small sluice trough that was being built on a small stream at the south base of the knob. Washing the ore in this trough would improve its quality, but in order to obtain a marketable ore of good quality the mine run ore would have to be crushed and then treated in jigs to separate it from the sand. The apparent small size of the ore body will, however, not justify the installation of a plant equipped with such machinery.

LECKIE-MOSS MINE.

On the south slope of Garden Mountain, which forms the south rim of Burkes Garden, William Leckie, of Welch, W. Va., opened several pits. (See fig. 31.) They are near the road that passes over a low saddle from the southwest corner of Burkes Garden into Lick Creek Valley. The ore occurs in Oriskany sandstone, and is opened by several shallow trenches about 500 feet below the saddle.

The general structure of Burkes Garden is a short anticline, or elongated dome, the inclosed valley which is underlain by Ordovician and Cambrian

limestone being surrounded by a rim of mountains composed of Clinch sandstone, which dips away in all directions. The low saddle in the rim at the southwest edge of the garden is apparently caused by a minor fault, which offsets the mountain-making sandstone. (See fig. 32.) Fine-grained

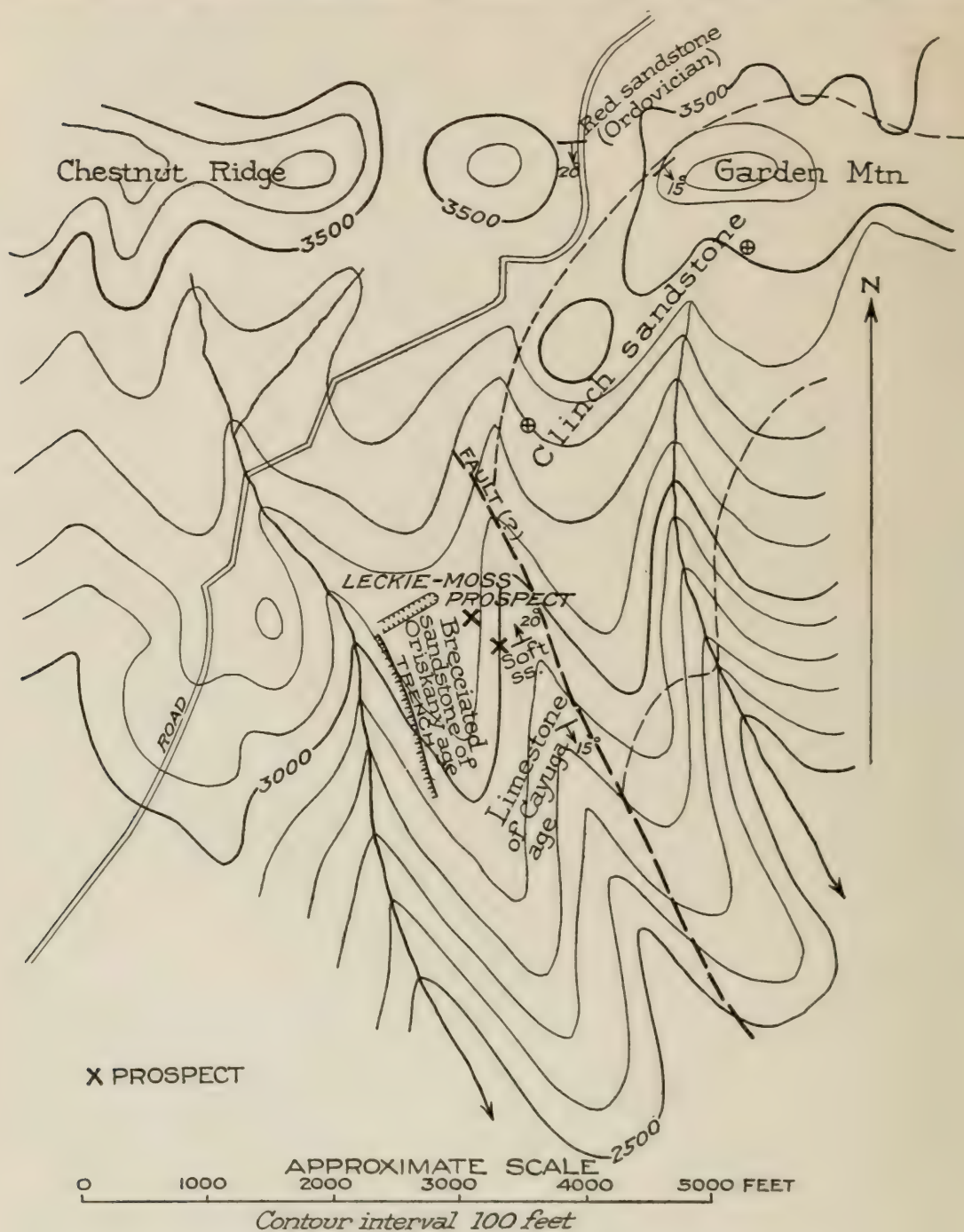


Fig. 32.—Sketch map of the Leckie-Moss prospect, Bland County.

laminated limestones, presumably of Cayuga age, which crop in ravines below ore-bearing Oriskany sandstone on the outer slope, dip 15° south into the Lick Creek syncline. The limestone carries a small amount of galena.

Prospecting was first done on the property by Moss and Perry, of Bluefield. In 1918, William Leckie, of Welch, W. Va., and George Moss, of Burkes Garden, organized the Leckie-Moss Co. to operate the mine, and a small quantity of ore was reported to have been shipped by them through Burkes Garden to the railroad, but the long haul over two mountains to the railroad was not found to be profitable. The openings consist of several pits and trenches on the top and sides of a flat-topped spur, 3,000 feet in altitude. (See fig. 32.) A pit 15 feet square and 20 feet deep on the top of the bench exposes a 5-foot bed of almost solid siliceous psilomelane. In the south wall of the vein there is brown clay and sand containing some wad and in the north wall there is a bed of purplish sticky clay in sand. The clay, which is believed to have been derived from a bed of limestone, dips 55° N., probably overturned. Just below, a small pit exposes soft white slabby sandstone, trail marked and containing scolithus, which is characteristic of a sandstone at the top of the Clinton formation in this vicinity and recognizable at many places northeastward into Maryland, where it is called Keefer sandstone member. E. O. Ulrich recently found fossil Eurypterids (*Hughmilleria*) in black shale interbedded with the sandstone at this horizon in the vicinity of Big Stone Gap in southwestern Virginia, which he regards as the same as those found in the Keefer sandstone member in Maryland. A trench 3 feet deep and 150 feet long on the west slope of the spur exposes brecciated sandstone cemented by manganese oxide, and large masses of the highly siliceous ore, too low grade to ship without treatment, lay on the dump. The ore, therefore, occurs in brecciated sandstone of Oriskany age and in an underlying deeply weathered zone between it and the limestone of Cayuga age. Chert of Oriskany age overlies the sandstone, and manganese ore float associated with chert fragments is reported to occur along the south slope of Garden Mountain to the east, especially on J. B. Meek's property, but it has not been prospected.

CHESTNUT RIDGE PROSPECT.

On the lower south slope of Chestnut Ridge, about 4 miles southwest of the low saddle in the southwest rim of Burkes Garden, two openings were made by T. E. Perry in 1917. One opening was near the base of the hill and another about one-third way up the slope, where a pit 12 feet deep was sunk. The ore occurs in soft layers between thin sandstone beds over-

lying the limestone of Cayuga age, and some ore occurs also in the sandstone. Some large lumps of good-grade ore were encountered and a car load, which is reported to have run 44 per cent of manganese, was hauled to Tazewell and shipped to Pennsylvania in the fall of 1918. The deposit is probably at the base of the Oriskany and in the underlying sandy beds of Cayuga age. This prospect was not visited by the writers but was seen by Thomas L. Watson, State Geologist, in 1917.

TAZEWELL COUNTY.

ADZ RIDGE PROSPECT.

Manganese ore float is scattered over the south slope of the east-west spur of Big Ridge, called Adz Ridge, on the south side of Nye Cove, 4 miles south of Graham. It is an anticlinal ridge, the anticline plunging southwestward but apparently continues into Brushy Mountain on which the Buckhorn Mountain prospect is located. No prospecting has been done on the property but R. B. Miller had collected small piles of ore from the surface at various places along the south foot of the ridge. Some of the ore was psilomelane, in part cementing chert fragments, but most of it was siliceous iron ore. Fragments of chert and coarse sandstone of Oriskany age are associated with the ore float, and the ore probably replaced sandstones of the Oriskany and associated formations.

BUCKHORN MOUNTAIN PROSPECT.

The Buckhorn Mountain prospect, opened by R. B. Miller, of Bluefield, W. Va., is 4 miles south-southwest of Graham, Va., on the south side of Nye Cove. (See fig. 27.) It is near the north base of Brushy Ridge, a low east-northeastward-trending foothill of Buckhorn Mountain. Work at this locality was done by Mr. Miller in 1917 and in November of that year one carload of iron ore and one of manganiferous iron were shipped. The ore was hauled by wagon over East River Mountain to Graham, a distance of 6 miles by wagon road. The prospect, which consists of two cuts, is on a saddle connecting Brushy Ridge with a low hill to the north, and is 200 feet above the east fork of Cove Creek. The low hill is formed by chert and sandstone of Oriskany age, apparently in a low anticline. The saddle is underlain by clay and more or less weathered sandstone, probably residual from rocks of Cayuga age.

The cuts are nearly parallel and are about 100 feet apart. The one that is to the south is 75 feet long, 8 to 10 feet deep, and several feet wide, and

trends N. 65° E. The yellow laminated clay into which it has been dug contains veins and irregular masses, as much as 3 feet in their longest dimension, which are composed of manganese oxides and brown iron oxide. The manganese and iron oxides are intimately mixed and although they can be in part separated, it would be impossible to obtain a high-grade manganese ore.

The other cut is 75 feet long, several feet wide, and 8 feet deep at the deepest place, and trends east. It has been made in fractured sandstone and in clay in which there is a small quantity of chert. Masses of brown iron ore, several feet in their longest dimension, occur in the sandstone both as a replacement material and as a fissure-filling. Some of the ore contains much sand and some of it displays botryoidal surfaces. Only a very small quantity of manganese oxide is mixed with it.

NYE COVE PROSPECTS.

Several openings have been made recently on the property of the H. Bowen estate in Nye Cove a few miles southwest of Graham (see fig. 27), but no manganese ore had been shipped before the time of visit (Aug. 27, 1918).

A few shallow pits are on the north slope and near the crest of a low ridge, and at places for a distance of almost one-fourth mile to the west. They are a short distance west of the Buckhorn Mountain prospect described above. Masses of brown iron ore, weighing as much as a few hundred pounds, in which there are manganese oxides were observed on the surface and some such masses were found in the pits. They are mostly free from sand and a few of them consist entirely of manganese oxides, but due to the intimate mixture of the iron and manganese any ore that may be marketed from this locality would be classed as a mangiferous iron ore. The pits that have passed through the soil have penetrated a sandy clay, which is probably residual from rocks of Cayuga or Oriskany age.

Specimens of high-grade psilomelane shown to the writers are said to have been found on the hill that is south of the east fork of Cove Creek near its junction with the west fork. Small openings were made on this hill but they were not visited.

A shallow cut, which is on the south slope of an eastward-trending ridge half a mile north of the east fork of Cove Creek and 400 feet above the creek, was dug in yellow clay and it yielded a few small platy and irregular-shaped masses of psilomelane. Such masses were observed on the surface over an area of several acres in the vicinity of the cut but their

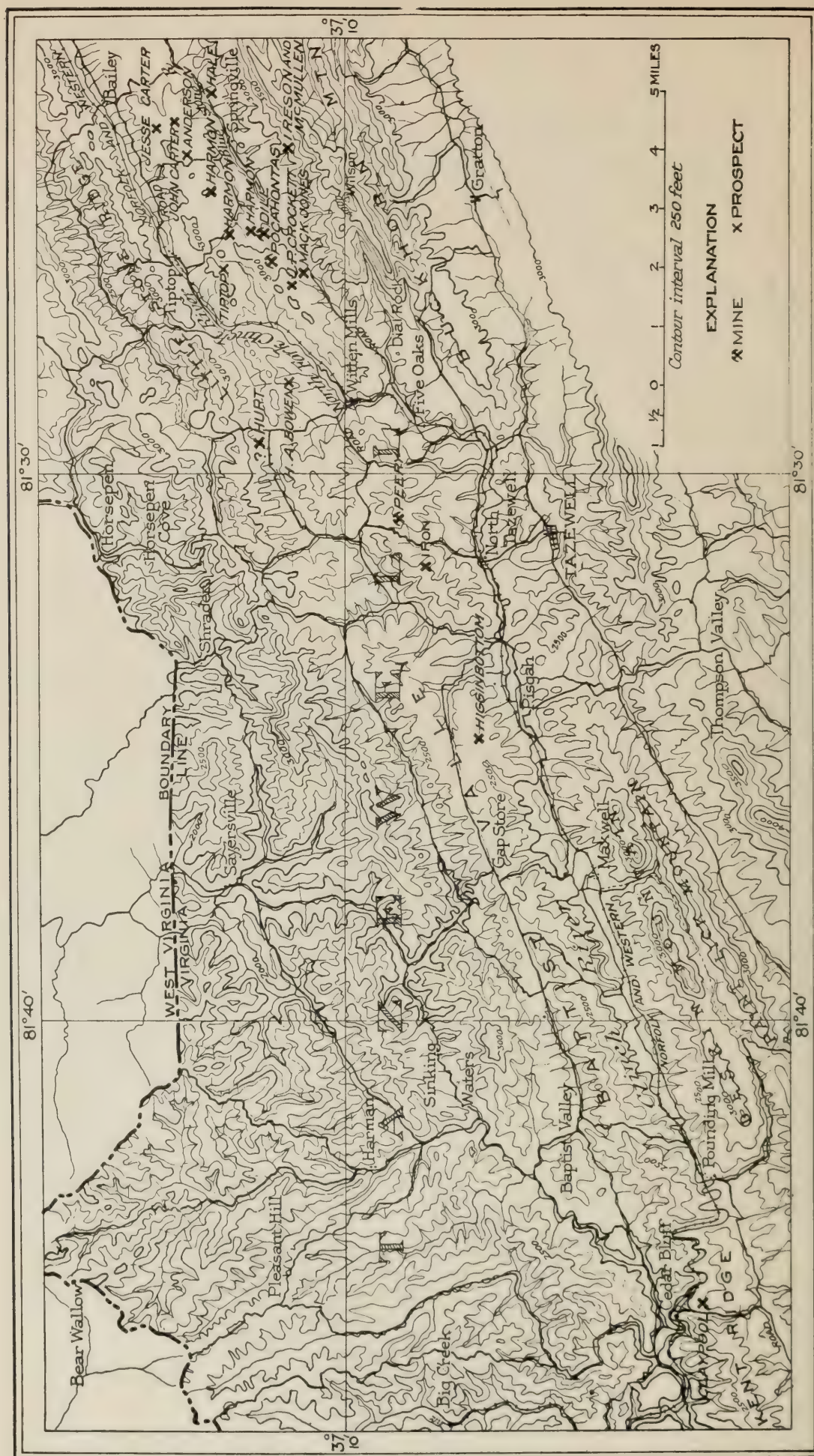


Fig. 33.—Map of a part of Tazewell County, showing the location of the manganese mines and prospects near Tiptop, Tazewell, and Cedar Bluff.

small quantity appears to militate against the possible discovery of a workable ore body. Furthermore, much of the psilomelane contains a large percentage of sand. The clay at this locality is apparently residual from rocks of Cayuga age, which dip to the south.

Boulders of manganiferous iron ore have been found on the surface on the rough south slope of East River Mountain about 500 feet above the west fork of Cove Creek and 2 miles west of its junction with the east fork of this creek. They were not followed by the writers up the mountain slope to their source. No prospecting has been done except to pile up some of the boulders. They are composed of the fibrous variety of brown iron oxide and of steel-blue psilomelane which are intimately mixed. (See Plate XVI.)

HALE PROPERTY.

The Charles Hale property, about 1 mile east-northeast of the village of Springville, (see fig. 33), had been leased by the Tiptop Mining Co., at the time of visit (August 9, 1918). No prospecting had been done then. Pieces of manganese and iron oxides, weighing a fraction of a pound each, were found by the writers in red sandy clay on the top of the east end of a hill that is just south of a rock quarry in the Knox dolomite south of Bluestone River. The crest of the hill at this locality is nearly level and is a part of a terrace about 50 feet above Bluestone River on which river gravels composed of waterworn fragments of sandstone occur. The sandy clay in which the pieces of manganese and iron oxides were found appears to be part of the stream deposit on the terrace. The quantity of manganese ore likely to be found in this clay will probably be small.

CARTER PROSPECTS.

The John Carter prospect is on land owned by John Carter, $2\frac{1}{2}$ miles east of Tiptop station, at the head of a small draw that is tributary to Bluestone River. (See fig. 33.) Work has been done here recently by S. H. Meem, of Bluefield, W. Va., but no ore had been shipped before the time of visit (August 10, 1918). The main group of openings, which consists of 4 pits as much as 10 feet deep, is on a north hillslope at the head of a southeastward-trending hollow. The deepest pit on the flat top of the bench is 15 feet deep. The pits were dug in brown residual clay derived from the Knox dolomite, of which there are exposures in the vicinity. Masses of manganese and iron oxides and fragments of chert cemented by these oxides were found in the clay. A few tons of the ore had been gathered in a pile near the pits. The masses of ore were more or less porous

and shelly and contained some chert. Most of the chert could be eliminated by hand-picking and trimming with a hammer, and some of the iron could also be eliminated by hand-picking, but the best grade of ore that could be obtained in marketable quantity by this or any other method would probably not contain more than 35 per cent of manganese. The accompanying analysis represents the chemical composition of a 50-pound sample collected by Mr. Carter from the best parts of the ore and it shows that a small part of the ore has a high manganese content.

Analysis of manganese ore from the John Carter prospect.

[A. D. Bazzara, analyst.]

Manganese (Mn)	50.00
Iron (Fe)	9.89
Phosphorus (P)	.05
Silica (SiO ₂)	6.46

A few small openings are stated by Mr. Carter to have been made on his place in the chert hills northeast of these pits but he said the quantity of ore found in them was less than at the above-described openings. Some good-grade float ore containing some manganite was seen on the hillslopes near the road to Bailey.

Ore was also reported on the Jesse Carter farm northwest of the John Carter place in chert hills apparently at or near the fault contact of the Knox dolomite with Devonian or Carboniferous rocks. No prospecting had been done on the property and it was not visited by the writers.

ROBERT ANDERSON PLACE.

The Robert Anderson place is one mile northwest of the village of Springville and 1¾ miles east-southeast of Tiptop station. No prospecting has been done on this place but masses of manganese oxides, weighing as much as 3 pounds, have been found here and there on the surface, and the mining rights had been leased by W. B. Crawford, of Bluefield, W. Va., at the time of visit. Such masses were observed by the writers in red clay in a wagon road near the base of a hill just south of Mr. Anderson's house, but they do not appear to be sufficiently numerous to warrant more than a small amount of prospecting. Furthermore, the clay which overlies the Knox dolomite and in which the ore occurs, is not more than a few feet deep at the place where the ore was seen, as is shown by exposures of the Knox at the base of the hill and also along the small stream that drains the hollow in which Mr. Anderson's house occurs.

HARMON PROSPECTS.

The Harmon prospects are on the Harmon place, which is $11\frac{1}{4}$ miles west of the village of Springville and the same distance south-southeast of Tiptop station. (See fig. 33.) Work has been done at different localities on this farm within the last few years and 3 carloads of manganese ore are said to have been shipped. The ore is found in clays and at places it is associated with chert fragments that occur in the clays. The clays and the chert have been derived chiefly from the Knox dolomite, of which there are a few exposures in the vicinity. Shale exposed in the hill southwest of the house and along the road to the west opening is probably Nolichucky, and the ore is close to the contact with the shale and some of it is probably in the shale. (See fig. 34.)

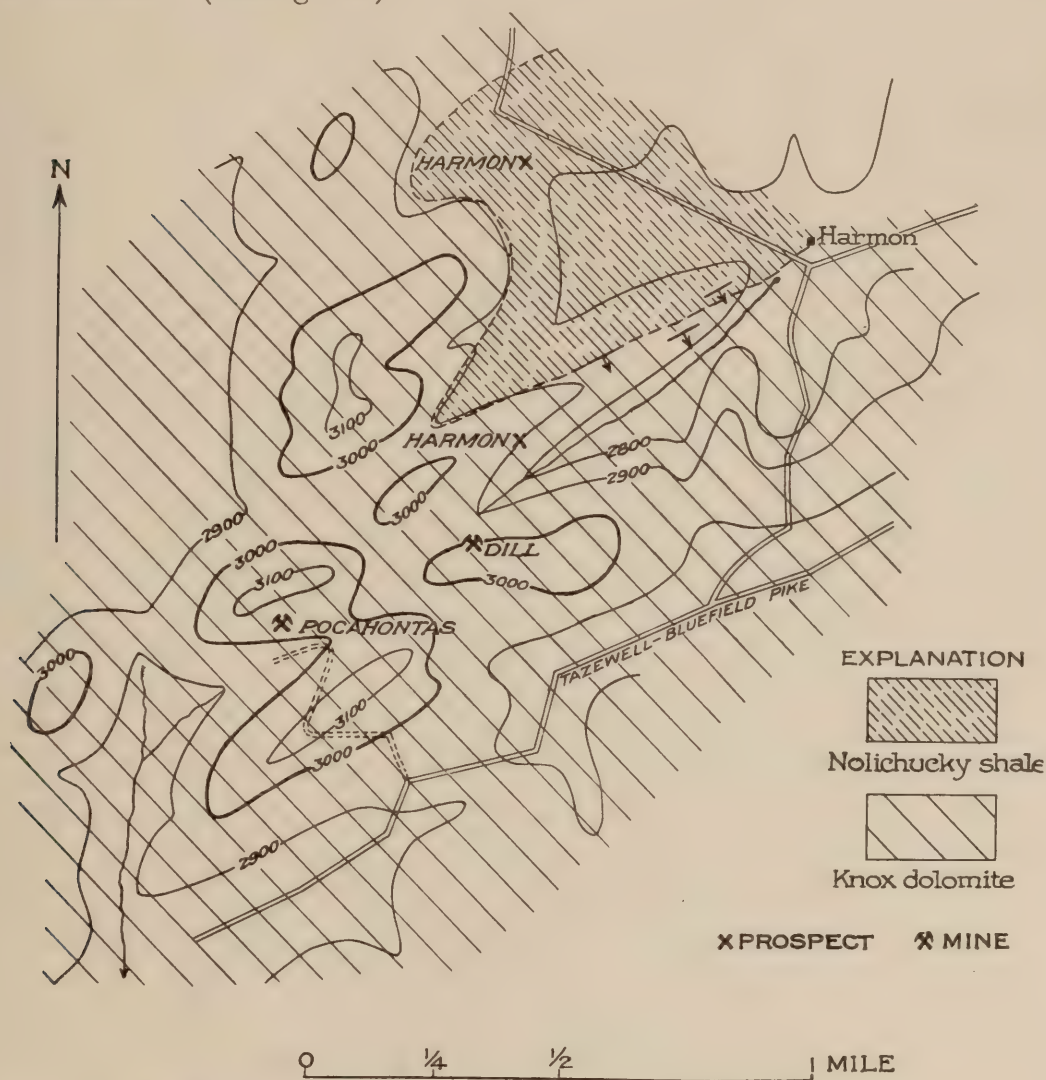


Fig. 34.—Sketch map of the Harmon, Dill, and Pocahontas properties, Tazewell County, showing shale, probably Nolichucky, underlying Knox dolomite and exposed in the vicinity of the manganese ore deposits.

A group of openings, which include a tunnel and several pits, are on the north side of a hollow half a mile southwest of Mr. Harmon's house. The manganese ore consists mainly of manganese oxides that form a coating on chert fragments or form the cementing material for a chert breccia, but some of it is nodular and free from chert. The marketed ore was washed by hand in a sluice trough on a small nearby stream. Some ore that had been concentrated in this way was seen at the time of visit, and consisted of more or less porous fragments of manganese oxides in which the amount of manganese was probably 40 per cent or more.

Several pits and cuts, as much as 30 feet deep, are half-a-mile northwest of Mr. Harmon's house. They occur at places along the west side of a wagon road at the east base of a hill for a distance of more than 200 feet. They penetrated yellow clay and all of them revealed a considerable amount of brown iron oxide and manganese oxides which occur intimately mixed in masses of large and small size. The iron and manganese oxides are present in about equal quantities. The manganese oxides are generally confined to the center of the masses and are thus surrounded by a shell of iron oxide, but some masses consist entirely of iron oxide. The masses are irregular or nodular in shape; they display botryoidal surfaces, which are colored red or yellow; and they contain more or less sand. The nodular and ferruginous character of the ore, the presence of shale outcrops nearby, and the absence of dolomite in the vicinity of the western pit, suggest that this deposit is in a zone between Knox dolomite and Nolichucky shale which is exposed beneath the Knox dolomite in the center of the anticline, from the Harmon house west to the western pit.

Manganese ore has been mined at other localities on the Harmon place, chiefly on chert hills north of the house, but the quantity obtained at such localities is said to have been small.

TIPTOP PROSPECT.

The Tiptop prospect is on the R. B. Dickerson farm, 1 mile southwest of Tiptop, Va., which is on the Clinch Valley division of the Norfolk & Western Railway. (See fig. 33.) Work was being done at this locality at the time of visit (August 9, 1918) by the Tiptop Mining Co., of which C. F. Linsemeyer, of Bluefield, is President and Manager.

The several openings at this locality have been made on or near a fault by which the Knox dolomite has been thrust northwestward upon shales and sandstones of Devonian or Carboniferous age. (See fig. 35.) The fault trends N. 60° E., and the dip of the fault plane, as shown in the

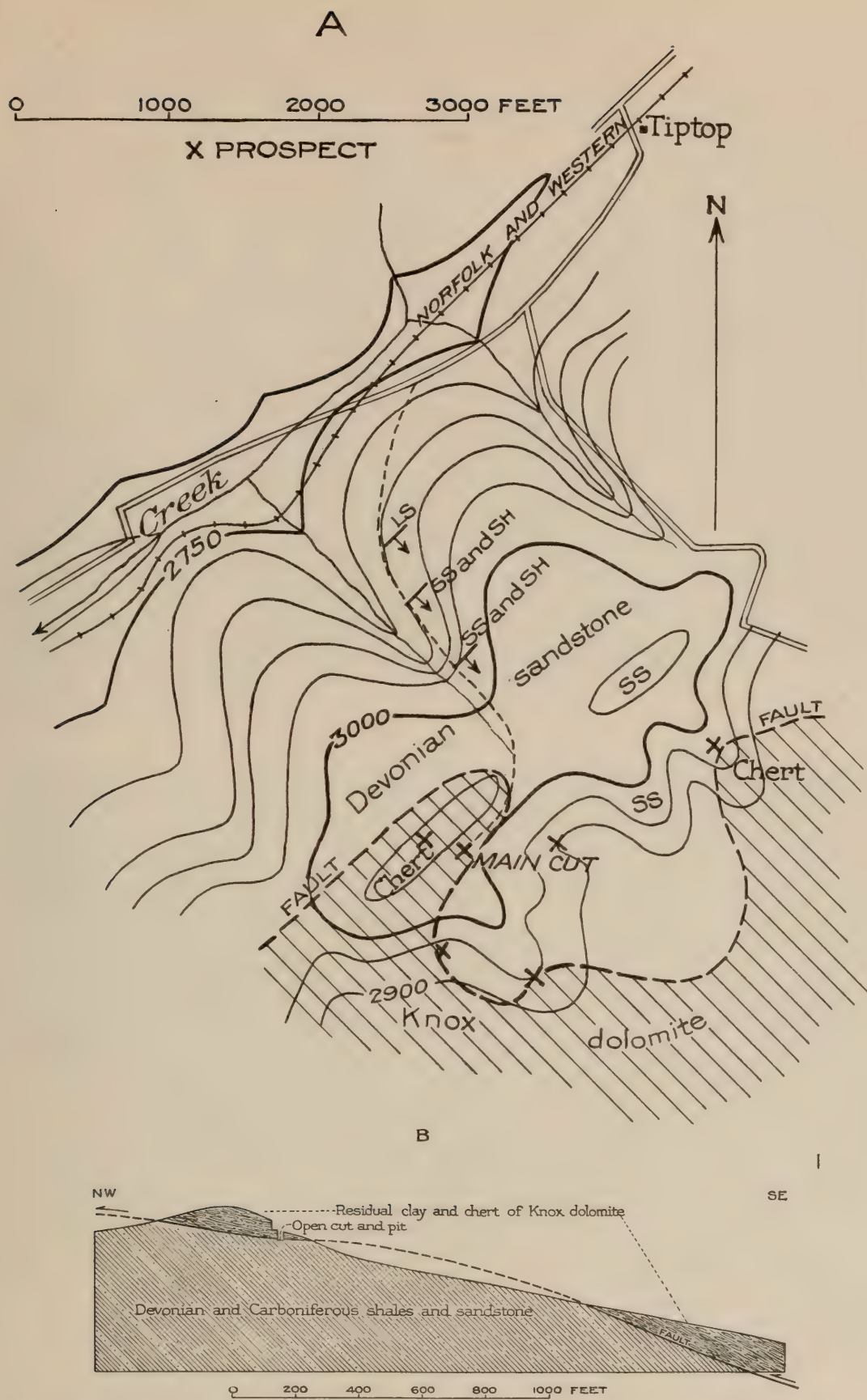


Fig. 35.—Sketch map (A) of the Tiptop prospect, Tazewell County, and sketch section (B) through the main cut.

figure, is very low toward the southeast. The Knox dolomite has been deeply weathered so that unaltered dolomite is nowhere exposed in or near the openings but is concealed by its residual clay and chert. There are, however, some exposures of the Devonian or Carboniferous rocks a short distance northwest of the openings.

The main opening, an open cut in which work was being done at the time of visit, is on the southeast slope of a hill at 3,000 feet above sea level. The cut extends into the hill 40 feet; and near its northwest end, which has a face 15 feet high, there is a pit 10 feet in depth. This cut and a smaller one joining it from the northeast have for the most part been made in a large mass of brecciated hard white chert. Oxides of manganese, mainly psilomelane, and some iron oxide cement the fragments of the breccia together and have partly replaced some of them. The quantity of these minerals is much less than that of the included chert fragments. Beneath the chert breccia there are several feet of red and yellow ochre-colored clays which contain a few chert fragments and a very small quantity of manganese oxide. This is underlain by dark-colored laminated clay that was probably derived from the shale of Devonian or Carboniferous age. The ore deposit is therefore at the fault contact of the Knox dolomite on the younger shales and sandstones.

A shaft, 20 feet deep, a short distance west of the cut on the slope of the hill, 3,040 feet above sea level, penetrated clay that contains chert fragments and passed into a ledge of chert. A few thin seams of fairly hard oxide of manganese and some rather pure soft ore, probably pyrolusite, were found here and there in the clay for a depth of 15 feet from the surface. A near-by cut to the southwest reveals a low grade of iron oxide cementing a chert breccia in red clay.

A small cut on the southeast slope of the hill below the main cut, at an elevation of 2,880 feet above sea level, exposes a deposit of low-grade bog manganese ore which contains chert fragments and clay. This deposit was probably formed in the bed of a small stream.

Two pits farther east that were visited were dug in ochre-colored clays that probably occur at or near the above-mentioned fault. No oxides of manganese were found in the clay although fragments of chert breccia that contained manganese oxide as a cementing material were found at the surface. One small cut that is east of the main cut was made in surficial material that consists partly of fragments of manganese-bearing chert breccia.



(A) Hand-cobbing manganese ore at the Tiptop prospect, Tazewell County.



(B) Hanging (west) wall of open cut of Capola Mountain mine composed of conglomeratic Oriskany sandstone.

The principal deposit of manganese ore as shown by the prospecting is in the main cut. The ore was freed as much as possible from chert by means of sledges and hammers (see Pl. XXXI), and it was planned to prepare by this method one carload of ore for shipment as an experiment. Although most of the chert was thus eliminated, the silica content of the marketed ore would still be comparatively high. The cobbled ore was said to run 35 per cent manganese and about 15 per cent silica. A better separation of the manganese oxides from the chert could probably be obtained by means of a crusher and jigs but the apparent small size of the deposit would not justify the installation of such machinery.

POCAHONTAS MINE.

The Pocahontas mine is on the John Stevens property, 2 miles south of Tiptop. (See fig. 33.) Before its present development it was known as the Tiller mine. On January 1, 1918, the Pocahontas Manganese Corporation bought the property, including the adjacent Crockett tract, 53½ acres in all. The Company is composed largely of men from Bluefield, W. Va., P. J. Kelley, being president, Edward Tiller, vice-president, and A. H. Baldwin, manager. Wm. C. J. Bartels was the superintendent. The mine is located on a low hill north of the Bluefield-Tazewell pike. A macadam road half a mile long was constructed to the pike, from which point it is 5 miles to Five Oaks station, the shipping point on the Norfolk & Western Railway.

The mine is on a chert hill in the Knox dolomite area, which trends northeast parallel to the general structure of the region. The deposit is in brecciated chert which crops profusely on the summit and northeast face of the hill. Red-coated iron oxide nodules and chert coated with a film of iron oxide were plentiful on the surface, and some manganese oxide occurs in veinlets in the chert. The deposit has been opened by several shallow pits, a shaft, and 3 tunnels. At the crest of the hill the manganese-bearing chert was opened by a trench 15 feet deep, several shallow pits, and a shaft 30 feet deep, which follow a nearly vertical zone of brecciated chert impregnated with ore. This zone was reported to become richer with depth. At the time of visit, June 20, 1918, two tunnels were being driven into the hill from the southeast side, about 100 and 200 feet, respectively, below the mouth of the shaft, but the ore zone had not then been reached in either. Both of these tunnels are reported to have later struck good ore under the shaft, the upper one at a distance of 214 feet and the lower one at 230 feet, from which an upraise of 182 feet was driven to meet the shaft. Southwest

of the shaft on the slope of the hill, 2 shallow pits encountered good-grade crystalline manganese ore in loose chunks in residual clay and chert. On the slope above the pits red-coated iron ore is plentiful at the surface. This deposit was reported to have been later opened by a tunnel 180 feet long, from which good-grade ore was taken out.

At the time of visit several tons of good-grade psilomelane was on the ore dump but none had been shipped. A carload was reported to have been shipped in August, 1918. An average analysis of a select sample of ore was said to show 38.4 per cent manganese, 3.1 per cent iron, 10.02 per cent silica. The general run of unwashed ore, however, ran 30 per cent silica. It was reported that \$60,000 was expended on the property, including the development of the mine, roads, pipe line, buildings, and washers. These were under construction at the time of visit and were completed during 1918.

DILL MINE.

The Dill mine is on the Walter Dill place, which adjoins the south side of the Harmon place, 2 miles south of Tiptop. It is on the north side of a chert hill lying just northeast of the Pocahontas mine and is apparently on the same mineralized zone in the Knox dolomite.

The mine was opened in 1918 by Carl Greever and H. A. Bowen, of Bluefield, W. Va. The workings consist of a long trench leading to an open cut 30 feet square and 15 feet high at the face, into which 2 tunnels follow ore zones for a short distance. The ore lies in pockets and zones in clay and wad with some chert and disintegrated sandy beds, which strike N. 60° E., and dip 65° SE. The hard ore is found in good-sized chunks and is largely crystalline and of high grade, as indicated by the following reported analysis of a carload of unwashed lump ore shipped to the furnace at Graham in August, 1918: Manganese, 48 per cent; iron, 1.3 per cent; silica, 7.1 per cent. Some of the ore mined was washed in the crude washer on the Harmon place, and half a carload of washed ore was hauled to Tiptop for shipment.

MACK JONES PLACE.

The Mack Jones place is 2½ miles southwest of the village of Springville and one-half mile southwest of the Pocahontas mine. (See fig. 33.) No prospecting has been done on this place, but a few fragments of chert that contain manganese oxide have been found in a southward-trending hollow in the chert hills north of the Tazewell road. It is in a northeast-

ward-trending belt that is underlain by the Knox dolomite. The Knox is not exposed at this locality but is concealed by chert and clay that have been derived from it. Whatever ore could be obtained here would be in small quantity and the silica content would be high. It is, therefore, not advisable to prospect for manganese ore at this locality.

J. P. CROCKETT PLACE.

The John Pat Crockett place is about 3 miles southwest of the village of Springville, and about one-half mile southwest of the Pocahontas mine. Although no prospecting had been done, fragments of manganese ore are said to have been found on the chert-covered hillslopes north of the Tazewell road, but none were found by the writers, who spent considerable time in looking for them. The property had been leased by the Pocahontas Mining Corporation.

This place is in an area that is underlain by the Knox dolomite, though at the locality where the fragments of manganese ore are said to have been found it is concealed by clay and chert fragments that have been derived from the dolomite.

IRESON AND McMULLEN PROPERTIES.

On the lower north slope of East River Mountain, southwest of Springville, manganese ore was reported on the Ireson and McMullen farms by S. A. White, of Welch, W. Va. The slope is underlain by Ordovician shale and limestone dipping into the mountain, which is capped by the Clinch sandstone and Clinton formation. Only small fragments of iron ore float, some possibly manganiferous, were found on the surface, and no pits had been dug. Samples of good fibrous brown iron ore had been collected from the higher part of the mountain, but the location was not disclosed. No manganese ore was seen by the writers.

HENRY A. BOWEN PROPERTY.

Manganese ore in chert, residual from Knox dolomite, was reported to occur as float on the farm of H. A. Bowen, 1 mile north of Witten Mills. Some of the ore is apparently at or near the fault contact of the Knox dolomite with the Devonian or Carboniferous rocks, similar to the occurrence of the deposits at the Tiptop prospect, but some ore lies on the slope of chert hills south of the fault. The property had not been prospected at the time of visit so was not examined by the writers.

LAURA HURT PLACE.

Ore was reported on the Laura Hurt farm $1\frac{1}{2}$ miles northwest up the hollow from Witten Mills. It is presumably in chert near the fault contact of the Knox dolomite with the Devonian or Carboniferous rocks. Prospecting had not been done on the property and it was not visited by the writers.

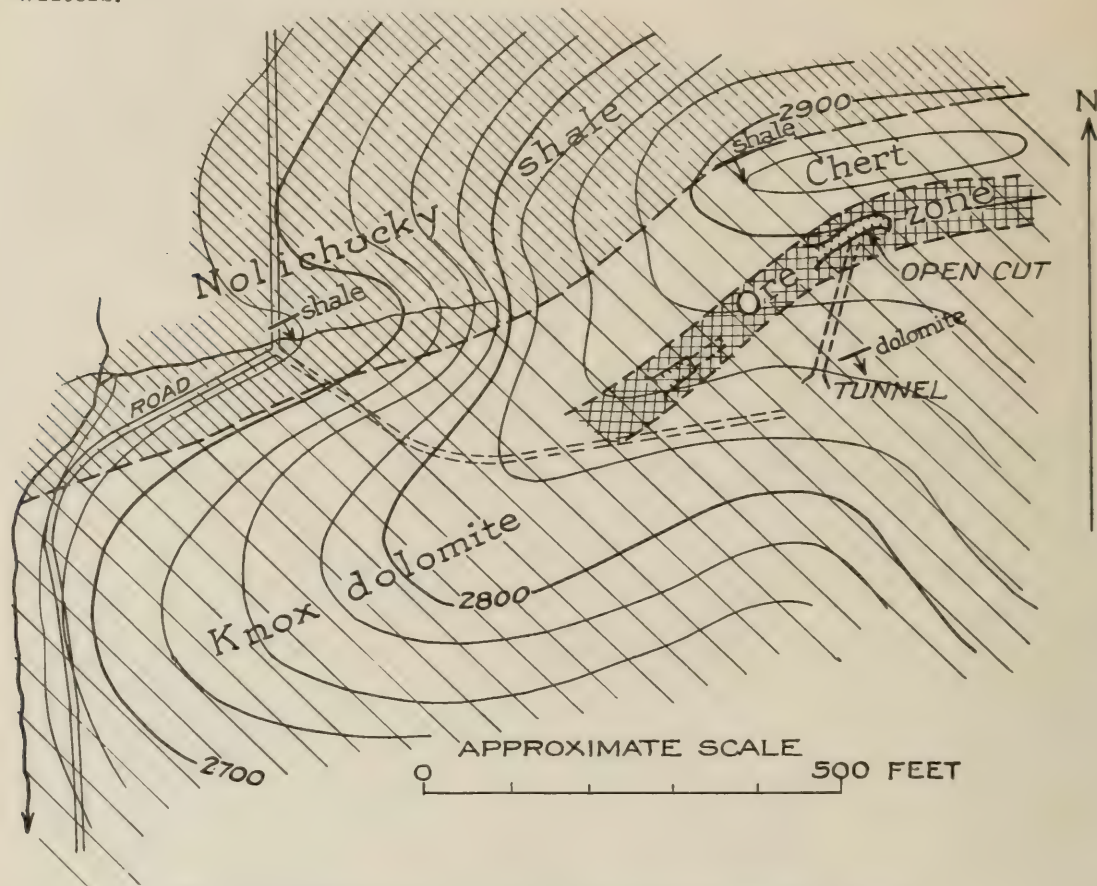


Fig. 36.—Sketch map of the Peery mine, Tazewell County.

PEERY MINE.

The Peery mine is on top of a chert hill in the Knox dolomite area, $1\frac{1}{2}$ miles north of North Tazewell, on the Norfolk & Western Railway. (See fig. 33.) It was opened in 1917 by J. P. Peery, of Tazewell. North of Clinch River there is a belt of chert hills which rise to a rather uniform level, about 2,800 feet above sea level. This forms a sort of upland level over the limestone and shale area and represents an old erosion surface, or peneplain. The mine is near the top of the highest part of the hill, 450 feet above the river, and is reached by a good public road. The ore zone is near the base of the Knox dolomite.

The mine consists of 2 open cuts and a tunnel. (See fig. 36.) The west cut is 15 feet wide and 25 feet long, running northeastward into the hill and has a 20-foot face. It exposes chiefly chert and clay wash, crossed by narrow zones of iron and manganese ore which dip steeply to the southeast. Yellow compact clay at the bottom seems to be residual from dolomite weathered in place, but its bedding was not shown. The east pit is 50 feet higher on the slope and is a narrow trench 50 feet long with a 30-foot face. Mostly iron ore occurs near the surface but some lumps of good crystalline manganese ore and chert are scattered through the yellow clay and are reported to form an ore body of considerable size in depth, dipping steeply southeast. Work was stopped in this cut at time of visit (August 17, 1918), and a tunnel was being driven 50 feet below to tap the ore body. The tunnel started in dolomite and was 150 feet long, but had not yet reached the ore body.

The ore was hauled to the river, where it was washed in a rotating cement mixer, which was run for 15 to 20 minutes and then dumped. The ore was next screened and cobbled from a belt conveyor. The screenings, although they were high in silica, were saved. Five carloads of washed ore mixed with screenings were reported to have been shipped. The larger pieces were in part high-grade crystalline ore which offset the low grade of the screenings. A shipment of 20 tons in 1917 is reported to have run 43.3 per cent manganese and 11.49 per cent silica.

Brown iron ore mined on a similar chert hill one-half mile to the southwest, across the hollow up which the road runs, was also washed in the Peery washer, and 3 carloads had been shipped to the Pulaski iron furnace.

The Peery mine, the iron mine, and the Higginbottom prospect next to be described, are in an ore zone which lies near the base of the Knox dolomite. This zone lies below massive dolomite beds which outcrop on the slopes to the southeast and above the purer clay shale of the Nolichucky. It is deeply weathered to clay and chert, that may represent a basal sediment of porous impure calcareous shale that contained disseminated manganese which was concentrated by solution and redeposition at the base of the weathered zone.

HIGGINBOTTOM PROSPECT.

This prospect is on the A. S. and A. J. Higginbottom farm, in the chert hills 1 mile north of Pisgah on the Norfolk & Western Railway, and 4 miles northwest of Tazewell. (See fig. 33.) These hills are composed of cherty Knox dolomite, and form a line of hills parallel to Clinch River.

Other hills capped by Nolichucky shale form a second line to the northwest. Much float ore lies on the northwest slope of the chert hills and on the tops of low adjacent knobs close to the contact of the dolomite with the shale. These conditions extend onto the O. E. Hopkins farm to the northeast and onto Reece Howery farm to the southwest. A narrow trench, 5 feet deep and 25 feet long, has been cut across the hill top on the Higginbottom property, exposing sandy clay soil containing chert fragments and some masses of good-grade manganese ore. The ore is chiefly dense psilomelane, in part cementing fragments of chert. Some of the ore fragments have botryoidal surfaces which are coated with iron oxide. Several tons of ore were on the dump but none had been shipped.

The arrangement of the hills suggests that the rocks are folded so that the ore zone is repeated, but there may be two ore-bearing zones. The tops of the hills are even and form an upland surface, which is apparently part of an old erosion surface, 2,700 to 2,800 feet above sea level. The thick residual clay in which the cut was dug is on this upland surface.

GOSE MINE.

The Gose mine is on the lower southeast slope of Rich Mountain, 3 miles north of Burkes Garden postoffice. (See fig. 31.) It was opened in 1917 by J. P. Gose, of Burkes Garden, on his own property. It is close to the road over the mountain from Tazewell to Burkes Garden. Several prospect pits were dug on the bench above the road, but the main pits are about 1 mile east of the road. They are reached from the valley bottom of Wolf Creek, just below where the stream comes out of Burkes Garden.

Rich Mountain is composed of Clinch sandstone, which dips south, and sandstone of Oriskany age makes benches and foothills on its south slope. The floor of Little Creek and of Wolf Creek below Little Creek is composed of Devonian black shale. On the road over Rich Mountain into Little Creek Valley the sandstone of Oriskany age is seen to be impregnated with manganese oxide, and the prospects above the road are in this zone. There are 3 main pits from which the ore was taken. (See fig. 37.) The lower one is about 100 feet above the valley bottom and is 15 feet deep. It exposes chiefly loose sandstone blocks in sand, in which dark bands carry some good ore. This seems to be wash of residual masses from above, but deep red clay at the bottom of the pit may represent bedrock in place. The largest opening is a pit 40 feet long, 20 feet wide, and 15 feet deep on a terrace 200 feet above the creek bottom. Sandstone wash 8 to 10 feet thick overlies soft white to buff sandstone and sandy bedded clay which

dips 30° S. toward the valley. The ore chiefly lies in the surface wash, largely at its base, where large masses of solid ore weighing 2 tons were taken out. The underlying bedrock has only a little manganese ore in narrow streaks. The next pit is 50 feet higher on the slope and is 5 feet deep in red sandy clay. This clay, which is better exposed in another trench 5 feet deep on the bench below, is a red sticky clay banded with white and stands vertical. It apparently represents the underlying limestone of Cayuga or

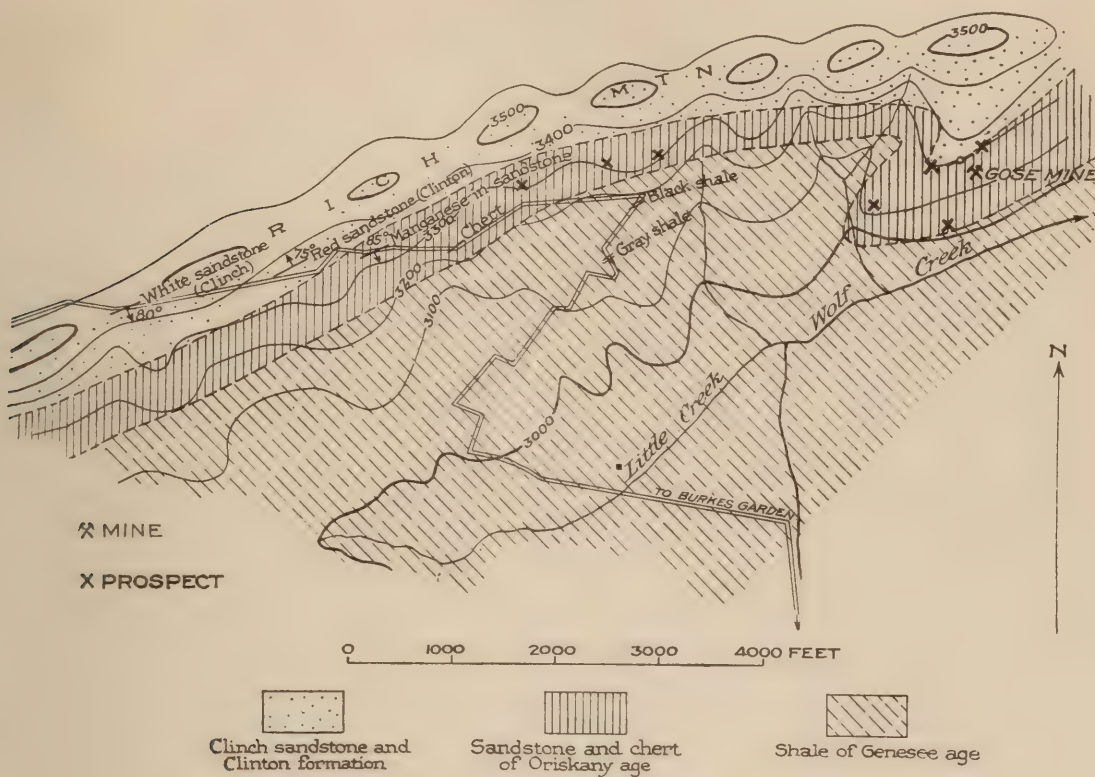


Fig. 37.—Sketch map of the Gose mine, Tazewell County.

Helderberg age. The ore is on the southeast wall of the pit and in the soil below the pit. Other pits to the northwest on the bench were reported also to contain ore.

The ore apparently occurs as a filling and replacement of brecciated sandstone, and has been concentrated in the residual sand and wash by the disintegration of the sandstone on the 3,100-foot terrace, which probably represents an old erosion surface. The distribution of the rocks at the surface in the vicinity of the mine indicates minor folding, the Oriskany apparently occupying a plunging syncline. This may account for the concentration of ore here. (See fig. 37.)

The ore is psilomelane, some dense and hard with brilliantly shiny black surfaces, some dull from impurities, such as inclosed clay and sandstone fragments. Analyzed samples are reported to have run as high as 45 per cent manganese and 6 per cent silica, but a carload lot shipped to the furnace at Temple, Pa., averaged only 35 per cent manganese. The shipped ore was hauled by truck over Rich Mountain to Burkes Garden Switch on the Norfolk & Western Railway. At the time of visit (August 16, 1918) 1 carload had been shipped and 5 tons of wash ore and 3 tons of lump ore were on the dump. The ore was washed in a small trough in Little Creek. The lump ore was broken up enough to be handled and was shipped in large masses without washing, so that the clay and sandstone which were inclosed in it reduced the quality of the shipment as noted above. The mine was closed down because of lack of help, the three Gose sons having been drafted for military service.

In the southern part of Burkes Garden, ridges of chert, derived from the weathering of Knox dolomite which underlies most of the valley bottom, show considerable float ore, but no prospecting has been done, so far as known, and the ore is believed to be insufficient to be mined profitably.

CRABTREE PLACE.

The Hite Crabtree place is in the valley of the South Fork of Clinch River 2 miles east-northeast of Gratton. (See fig. 31.) Manganese ore is said to have been found at a number of localities on this place north of the stream but no prospecting had been done before the time of visit (August 12, 1918). At that time a few fragments of manganese ore and one of iron oxide were observed on the surface of the hillslopes. The hills in this vicinity attain the level of the former valley floor and are underlain by the Knox dolomite and Chickamauga limestone, though these formations are usually concealed by residual clays and other surficial material.

CHARLIE JONES PLACE.

Fragments of manganese ore are reported to have been found on the surface on the Charlie Jones place 2 miles east-northeast of Gratton in the valley of the South Fork of Clinch River. No prospecting had been done on the place before the writers were in that vicinity in August, 1918, and the property was not examined by them.

S. W. BOWEN PLACE.

Manganese ore is said to have been discovered on the surface on the S. W. Bowen place in the valley of the South Fork of Clinch River 2 miles

southwest of Gratton, but no prospecting had been done on the place before the writers were in that vicinity in August, 1918, so they did not visit it.

YOST PROSPECT.

The Yost prospect is in the valley of the South Fork of Clinch River, $2\frac{1}{2}$ miles west of Gratton postoffice and $2\frac{1}{2}$ miles east of Burkes Garden Switch, on the Clinch Valley division of the Norfolk & Western Railway. (See fig. 31.) It is on a narrow bench on the north side of the valley and is on a tract of land that is owned by P. A. and Mrs. H. Yost. The bench is about 2,800 feet above sea level or 300 feet above the South Fork of Clinch River and has the same elevation as several similar benches on the north side of the valley. The uniform height of these benches suggests that they are remnants of a local valley floor.

Two tons of manganese ore are said to have been taken from a few pits 20 years ago, but none of it was hauled away. About 250 pounds of it had been obtained from a small pit that had been made shortly before the time of visit (Aug. 12, 1918).

A massive blue limestone (Chickamauga limestone) with a high dip to the south crops out at numerous places on the steep slopes below the bench, but on the bench it is generally concealed by a red, loamy clay which probably does not exceed a few feet in thickness. The manganese ore occurs as masses weighing as much as 50 pounds and is present in this clay and on the surface over an area of about 4 acres. That in the clay rests upon the limestone or in crevices in it. The ore consists mainly of psilomelane but partly of wad and some of it contains sand. Iron oxide occurs as small fragments but none of it is mixed with the manganese ore.

The occurrence of the deposit on a bench adjacent to Buckhorn Mountain to the north suggests that the masses of manganese ore may have been washed from the slope of the mountain but the failure thus far to discover such ore on the mountain militates against this possibility and favors the hypothesis that the ore was deposited in the clay on the bench on which the prospect occurs.

CLAYPOOL PROSPECT.

On the farm of E. D. Claypool, half a mile south of Cedar Bluff on the Norfolk & Western Railway, (see fig. 33), a small quantity of manganese ore float occurs over the northern slope of the chert hills that form the northeast end of Kent Ridge. The ore zone is near the base of the Knox dolomite. A small pit on the top of the hill showed a little iron ore

and some chert cemented with manganese. The deposit is of no value, but shows the southwestward continuity of the manganese-bearing zone near the base of the Knox in the vicinity of Pisgah and North Tazewell.

About 1 mile to the southwest similar ore is reported on the J. H. Nippon farm on Kent Ridge, also near the base of the Knox. This was not visited by the writers.

CORELL PROSPECT.

E. H. Warner has opened several pits on the W. T. Corell tract, 2 miles west of Asberry and 8 miles southwest of Tazewell. (See fig. 31.) The tract is in Poor Valley, well up on the south slope of Clinch Mountain, which is composed of Clinch sandstone having a high dip to the south. The prospect is on a bench 600 feet above Laurel Creek and exposes well-bedded buff sandstone, probably of Cayuga age, overlain by chert and sandstone, probably of Oriskany age. These rocks strike N. 65° E., and dip 40° S., beneath black shale of Genesee age, which composes the bottom of the valley of Laurel Creek.

The main trench, 600 feet above the Laurel Creek, is 50 feet long and 10 feet deep at its face. About one-quarter carload of ore, chiefly psilomelane with a red hematite coating one-half inch thick, has been taken out. The ore is largely nodular and occurs in seams in the buff sandstone, partly replacing it. Some crinoid stem impressions are preserved in the ore. A small pit 6 feet deep, 50 feet lower down the mountain, exposes thin layers of red hematite and manganese oxide replacing the sandstone. The low grade and small quantity of the ore and a 14-mile haul over Clinch Mountain to the railroad at North Holston discouraged further development.

Some good-grade manganese ore found in the stream wash below the prospect may have come through the gap in the mountain above. Clinch mountain here is double, each ridge being composed of Clinch sandstone forming an anticline, and the float may have come from older rocks exposed between the ridges in the center of the anticline.

SHORT PROSPECT.

A. T. Short, of Marion, has recently opened a deposit of manganese ore in the valley of Tumbling Creek, 3 miles northwest of Tannersville. (See fig. 31.) Manganese ore was mined in this vicinity 20 years earlier and was hauled to Saltville for shipment. An old shaft and tunnel are reported to have been dug near the Tazewell road, about half way up Clinch

Mountain, and other pits had been dug on the south side of the creek, about 1 mile southwest of the ford. Mr. Short reopened the deposits in 1918, and most of the ore taken out by him came from pits on the south side of the valley. The valley is synclinal, inclosing Devonian black shale of Genesee and Portage age, and the ore occurs in the sandstone and chert of Oriskany age that underlie the shale on the mountain slope. The ore consists of clean pieces of dense psilomelane. One carload of ore was reported to have been mined and shipped by way of North Holston, but on account of the 12-mile haul, mining was discontinued.

RUSSELL COUNTY.

WHITT PROSPECT.¹

The Whitt prospect is on the farm of James G. Whitt on Stone Mountain, 2½ miles northeast of Sword Creek station on the Norfolk & Western Railway. (See fig. 38.) The only work at this locality was done in 1898 by Col. Joe Harrison, of Tazewell. Stone Mountain is a hogback ridge about 4 miles long, trending nearly east between Sample Branch on the south and Sword Creek on the north, above which streams it rises to a height of 600 feet. It is monoclinal in structure and is composed chiefly of folded and faulted Silurian and Devonian sandstones and shales which are overturned and dip south at various angles.

The prospect occurs on the upper south slope of the mountain at an elevation of 2,460 feet above sea level and about 50 feet below a neighboring saddle known as Nipper Gap. The deposit occurs in the Clinch sandstone near its contact with the underlying red sandstone that has been called Bays sandstone in this area at a fault or shear zone that dips gently north-northwest diagonally across the bedding of the rocks, which here dip 40° S. It was opened mainly by a north-south trench 60 feet long and 8 feet or less deep. Though the trench had caved before the time of visit (November, 1918), and was overgrown with vegetation, manganese ore is exposed in places, mostly in the lower end of the cut, from which it is inferred that the deposit probably is 12 or 15 feet thick and dips with the shear zone northwestward into the mountain.

The deposit consists chiefly of a mixture of hematite, limonite, and psilomelane deposited by infiltration in, and replacement of, the crushed sandstone. The ore occurs largely as more or less porous layers laminated approximately parallel with the shearing, but includes also irregular masses

¹ Description by F. C. Schrader.

and botryoidal forms. It is not workable for manganese alone but may be workable for iron and manganese together, in which event some manganese ore of fair grade can probably be obtained by hand-sorting.



Fig. 38.—Map of parts of Tazewell and Russell counties, showing location of Whitt and C. A. Smith prospects.

C. A. SMITH PLACE.¹

Stains and films of manganese oxide as thick as a knife blade were observed on joint, fracture, and bedding planes of sandstone of Devonian or Carboniferous age on the farm of Charles A. Smith, 3 miles north of Honaker on the Norfolk & Western Railway. Also a layer of black siliceous wad about one inch thick coating the surface of a piece of sandstone was

¹ Description by F. C. Schrader.

observed in the creek wash below Mr. Smith's house. The quantity of the manganese oxides that were observed is so small that prospecting is apparently not warranted.

FORTNER PLACE.

The Fortner place, not visited by the writers, is on Moccasin Ridge about one-third of a mile southwest of the Helbert mine. (See fig. 39.) It is said to have surface indications of ore which are similar to those at the Helbert mine. This place has been leased by H. H. Kaylor but no prospecting has been done.

HELBERT MINE.¹

The Helbert mine is on the farm of A. J. Helbert on Moccasin Ridge, 6 miles southwest of Hansonville, and 7 miles south of Castlewood on the Norfolk & Western Railway. (See fig. 39.) Moccasin Ridge trends east-northeast and separates Copper Creek on the north from Moccasin Creek on the south, above which streams it rises to a height of 700 feet. The mine is on the northwest slope of the ridge about 100 feet below the crest, at an elevation of about 2,500 feet above sea level.

The mine was worked by H. H. Kaylor and J. P. Jones, who began work in July, 1918, and by the time of visit (Nov. 15, 1918) they had ready for shipment about 80 tons of ore which they had planned to ship to E. J. Lavino & Co., at Goshen, Va.

The deposit of manganese ore occurs near the contact of the Knox dolomite and the underlying Nolichucky shale, which dip 40° SE. Finely crystalline Honaker limestone crops out at a point 300 feet to the southwest of and 80 feet lower than the mine. The rocks containing the deposit are cherty shale which seem to have been in part silicified along a shearing or fault plane.

The mineral claim covers 10 acres but the deposit is for the most part contained in a rectangular area 500 feet long by 150 wide which trends east-northeast parallel with the strike of the rocks. It lies on a cleared slope and is therefore well adapted to being worked by plow and scraper or steam shovel. The deposit occurs mostly in six or more tabular ore-bodies which individually trend northwestward across the strike of the rocks and dip 60° SW. They lie in zones along joints that seem to have been produced by transverse shearing or faulting. The most important of the lodes are the three southwesternmost ones in the lower end of the

¹ Description by F. C. Schrader.

tract. They are about 10 feet apart, from 3 to 8 feet thick each, and individually have a known length of about 40 feet. The lowermost lode is opened by a cut 20 feet deep which has a face 26 feet wide along the course of the lode, and which is mostly in good ore. A 10-foot shaft which was sunk from the bottom of the cut near the face, but which was caved at the time of visit, is also said to be in good ore. This seems to show that the ore deposit at this place extends at least to a depth of 30 feet below the surface.

The ore occurs mostly in nodules and lumps irregularly embedded in light-reddish to yellowish residual clay and bedrock, and partly in overlying wash. It forms a filling in, and partial replacement of, crushed cherty material. The 2 to 3 feet of surface soil contains small fragments of ore, called "bean" ore, which merges downward into the coarse ore, and is therefore also workable. The ore is mostly soft, and consists chiefly of manganite and crystalline pyrolusite, with which some psilomelane and wad are associated. Iron in the form of hematite and limonite is sparingly present and the phosphorus content is low. Silica will probably average about 10 per cent. The following analyses were supplied by Mr. Jones:

Analyses of manganese ore from the Helbert mine.

	1	2	3	4	5
Manganese (Mn) .	60.35	54.31	54.68	51.46	43.03
Iron (Fe)	.99	.88	.26	1.00	1.80
Phosphorus (P) ..	.063	.06	.061	.....	.....
Silica (SiO ₂)	1.26	4.14	6.26	3.80	16.80

- 1. Analysis of picked sample.
- 2-5. Analyses of average shipping grade.
- 4-5. Analyses of Allegheny Ore & Iron Co.

It is said that the run of mine ore has yielded salable ore in the ratio of 10 to 1. Judging from the appearance of the deposit, this average can not be maintained if the mine is worked on a larger scale. A considerable portion of the ore was being hand-sorted and shipped without further treatment. Some was being screened to several sizes in large bins, and some was being washed in a hand washer. The washer, which is of the rocker type, is 14 feet long and 4 feet wide. It was 1,000 feet from and 300 feet

lower than the mine in a gulch tributary to Copper Creek, the water being supplied by gravity from a nearby spring. The installation of a double log washer was being considered at the time of visit. If the amount of fines left in the waste after treatment continues the same with further work, it seems that a jig may be desirable to concentrate this class of ore.

WASHINGTON COUNTY.

FULLEN PROSPECT.

Manganese ore was reported on the W. A. Fullen property, on the south slope of Clinch Mountain 2 miles west of Zenobia and 5 miles northeast of Mendota on the Virginia and Southwestern Railroad. (See fig. 39.) On the mountain slope 170 feet above the road, an open cut 20 feet into the hill, with a face 15 feet high, exposes soft green sandstone and dark shale, somewhat iron-stained. A little nodular iron ore and chert are strewn over the surface, but no manganese ore was observed by the writers. It appears to be in the basal part of the Devonian shale, close to the underlying sandstone of Oriskany age.

SCOTT AND RUSSELL COUNTIES.

COPPER RIDGE PROSPECTS.

On the slopes of Copper Ridge manganese ore float occurs in many places north and northwest of Mendota (see fig. 39), and may be seen along the road to Castlewood, but it does not appear to be in minable quantity. No prospects were reported in Russell County to the writers, but in Scott County prospecting has been done $2\frac{1}{2}$ miles south of Dungannon on the Powuers property by Ellis and Crawford, of Bluefield. This prospect is described below. Copper Ridge is composed of Knox dolomite, and its surface is strewn with residual chert fragments from this dolomite. The ore is associated with the chert.

SCOTT COUNTY.

POWUERS PROSPECT.¹

The Powuers prospect is on the L. L. Powuers' farm, $2\frac{1}{2}$ miles south of Dungannon on the Carolina, Clinchfield & Ohio Railroad. (See fig. 39.) It is on a terraced spur of the upper northwest slope of Copper Ridge, at

¹ Description by F. C. Schrader.

an elevation of about 2,220 feet above sea level or 250 feet above Clinch River, which is $11\frac{1}{2}$ miles northwest of the prospect.

The openings were mostly made many years ago and are now caved in and overgrown with vegetation, though a little work was done in 1918. At the time of visit (Nov. 16, 1918) a lease on the property was held by Messrs. Crawford and Ellis, of Bluefield, W. Va., but no work was being done at that time.



Fig. 39.—Map of parts of Scott and Washington counties, showing location of manganese prospects in the vicinity of Mendota.

The openings, which consist of 10 or more pits and trenches, occur within an east-west belt about 700 feet long and 200 feet wide. The pits are as much as 25 feet square and the trenches are as much as 100 feet long. None of them are more than 10 feet deep.

The ore deposit as revealed on the surface and in the openings is in whitish sandstone or chert and clay, which are residual from the lower part of the Knox dolomite near its contact with the Nolichucky shale. The formations dip gently to the south-southeast and the contact between them is possibly a fault. The ore is mostly nodular, having botryoidal, mam-

millary, and other surface forms, and is a manganiferous iron ore consisting of the iron oxides hematite and limonite and of the manganese oxides, psilomelane, manganite, and pyrolusite. These minerals are revealed not only in the openings, but as stains in the surficial clay and as fragments scattered over the surface. Under favorable shipping conditions the deposit would possibly be workable chiefly for its iron content, and the manganese ore, some of high grade, could probably be separated as a by-product. Several tons of high-grade manganese ore now at Dungannon is said to have been hauled many years ago from the Powuers prospect.

CHARLES PERRY PROSPECT.

Old iron workings on the Charles Perry tract, 1 mile north of Snowflake and 8 miles northeast of Gate City (see fig. 39), are on the south slope of an outlying ridge of Moccasin Ridge, on the north side of Big Branch. The ridge is covered with chert fragments derived from the Knox dolomite, which has a low dip to the southeast. Old trenches 5 feet deep expose decomposed calcareous shale beds and yellow boggy ochre. Manganese ore was reported to occur at this locality but none was seen by the writers. A tunnel 75 feet long has recently been driven in dolomite, in part brecciated and stained by iron, but no body of ore was encountered.

ROBINSON PROSPECT.

Old iron workings on the R. C. Robinson tract, 1 mile north of Snowflake and 8 miles northeast of Gate City, consist of a deep trench and a large waste dump which shows cavernous iron ore with a core of pyrite. The trench is in a small hollow just north of the Perry prospect, previously described, and is also in Knox dolomite. The deposit has recently been opened by J. H. Peters, E. D. Rollins, and Ryland Craft, of Gate City, who report samples of manganese ore from the property to have yielded the following analyses:

	1	2
Manganese (Mn)	36.7	33.7
Iron (Fe)	17.6	23.3
Phosphorus (P)	.02	.05
Silica (SiO ₂)	3.5	4.3

No manganese minerals were seen by the writer. The iron ore may, however, carry some manganese, but it would contain a smaller percentage of manganese than is given in the above analyses.

WISE COUNTY.**BUTCHER CREEK HILLS.**

On the hill tops north of Butcher Creek, one-half mile north of Buffalo School and 2 miles southwest of Little Stone Gap, there is considerable iron and manganese ore float associated with chert fragments of Helderberg age. In this region black shale of Genesee age rests unconformably on highly fossiliferous cherty limestone of Helderberg age, rocks of Oriskany, Marcellus, and Hamilton ages being absent. The upper beds of Helderberg age carry a profusion of corals which are reported by E. O. Ulrich to be of Becraft (uppermost Helderberg) age. The unconformity between the Helderberg limestone and the overlying shale is marked by a thin layer of limonite iron ore at many places, and at one place a thin much disturbed remnant of fossiliferous shale of Hamilton age is associated with the ore. At the above-mentioned locality manganese oxide is associated with the iron ore, occurring mostly as chert breccia cemented by psilomelane, but some small fragments of pure psilomelane also occur as float. No openings on the ore were observed and the quantity of ore is probably small.

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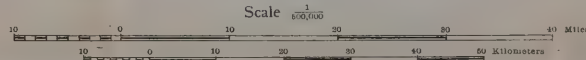
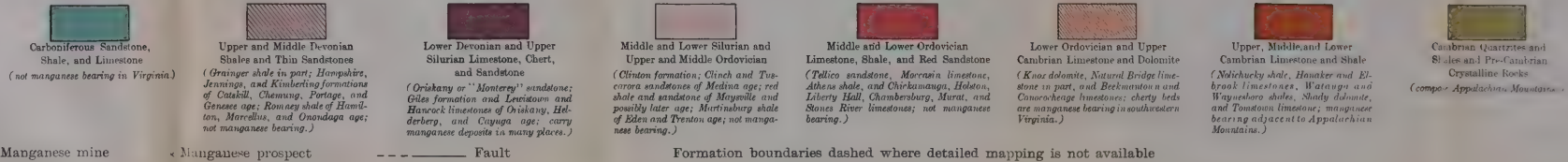
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VIRGINIA GEOLOGICAL SURVEY
THOMAS LEONARD WATSON, DIRECTOR

GEOLOGIC MAP OF WESTERN VIRGINIA

Compiled by G. W. Stose from published and manuscript maps of the U. S. Geological Survey and from the geologic map of Virginia by Thomas L. Watson, supplemented by personal knowledge

EXPLANATION



LIST OF MANGANESE MINES AND PROSPECTS IN WESTERN VIRGINIA (LOCATED AND NUMBERED ON MAP)

(DOES NOT INCLUDE THOSE ON EAST SIDE OF VALLEY OF VIRGINIA)

FREDERICK COUNTY	GILES AND BLAND COUNTIES
1. Mineral Ridge mine	67. Storage mine
2. Moore's Orchard prospect	
3. Nelson No. 1 prospect	
4. Nelson No. 2 prospect	
5. Limestone Ridge prospect	
SHENANDOAH COUNTY	BLAND COUNTY
6. McGraw prospect	68. Rock Branch prospect
7. Bl. 1st prospect	69. Dismal Creek prospect
8. Upper Limestone prospect	70. Coalfield mine
9. Limestone mine	71. Ticker prospect
10. Burket m. mine	72. M. mine prospect
11. Burket m. mine	73. Wil. am. prospect
12. Burket m. mine	74. Burket m. mine
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354. Burket m. mine	416. Burket m. mine
355. Burket m. mine	417. Burket m. mine
356. Burket m. mine	418. Burket m. mine
357. Burket m. mine	419. Burket m. mine
358. Burket m. mine	420. Burket m. mine
359. Burket m. mine	421. Burket m. mine
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361. Burket m. mine	423. Burket m. mine
362. Burket m. mine	424. Burket m. mine
363. Burket m. mine	425. Burket m. mine
364. Burket m. mine	426. Burket m. mine
365. Burket m. mine	427. Burket m. mine
366. Burket m. mine	428. Burket m. mine
367. Burket m. mine	429. Burket m. mine
368. Burket m. mine	430. Burket m. mine
369. Burket m. mine	431. Burket m. mine
370. Burket m. mine	432. Burket m. mine
371. Burket m. mine	433. Burket m. mine
372. Burket m. mine	434. Burket m. mine
373. Burket m. mine	435. Burket m. mine
374. Burket m. mine	436. Burket m. mine
375. Burket m. mine	437. Burket m. mine
376. Burket m. mine	438. Burket m. mine
377. Burket m. mine	439. Burket m. mine
378. Burket m. mine	440. Burket m. mine
379. Burket m. mine	441. Burket m. mine
380. Burket m. mine	442. Burket m. mine
381. Burket m. mine	443. Burket m. mine
382. Burket m. mine	444. Burket m. mine
383. Burket m. mine	445. Burket m. mine
384. Burket m. mine	446. Burket m. mine
385. Burket m. mine	447. Burket m. mine
386. Burket m. mine	448. Burket m. mine
387. Burket m. mine	449. Burket m. mine
388. Burket m. mine	450. Burket m. mine
389. Burket m. mine	451. Burket m. mine
390. Burket m. mine	452. Burket m. mine
391. Burket m. mine	453. Burket m. mine
392. Burket m. mine	454

IA

geologic map



Middle and Lower
Limestone and Shale
Hale, Hensler and El-
lison, Watauga and
Shales, Shaly dolomite,
limestone; manganese
occurs in Appalachian



Cambrian Quartzites and
Shales and Pre-Cambrian
Crystalline Rocks
(compose Appalachian Mountains.)



14. Capola Mountain mine
15. Little North Mountain prospect
16. Riffey Mountain prospect
17. Yellow Springs prospect
18. High Head prospect
19. Gap Mountain prospect
20. Scott prospect
21. Oregon mine
22. Philadelphia mine
23. Powells Fort mine
24. Cameron prospect
- BATH COUNTY
25. Gillett prospect
26. Stephenson prospect
27. Little Piney Mountain prospect
- ALLEGANY COUNTY
28. Falling Spring prospect
29. Covington prospect
30. McGraw Gap
31. Vowles mine
32. Rich Patch mine
- BOTETOURT COUNTY
33. Horton prospect
34. Cook mine
35. Burman prospect
36. Purgatory Mountain prospects
- CRAIG COUNTY
37. Fenwick iron mine
38. Red Brush prospect
39. Potts Valley prospects
40. Peters Hill prospect
41. Cliff prospect
42. Chev mine
43. Givens prospect
44. Hoffman prospect
45. Hoffman mine
- MONTGOMERY COUNTY
46. Gap Mountain prospects
- GILES COUNTY
47. Carrie prospect
48. Laine prospect
49. Price prospect
50. Spruce Run Mountain prospects
51. Herron property
52. Denison prospect
53. Hoge-Laine prospect
54. Collins place
55. Simpkins prospect
56. Short Mountain prospect
57. Snidow place
58. Eaton property
59. Linkous and Shumate prospect
60. Stowe mine
61. Beamer prospect
62. Hare prospect
63. No Business Creek prospect
64. Flat Top prospects
65. Johnson prospect
66. Thompson place
80. R. R. Nelson prospect
81. Henaker prospect
82. Angel prospect
83. Starling prospect
84. Aker prospect
85. Lambert place
86. Guy place
87. Bishop place
88. Big Ridge prospect
89. East River Mountain prospects
90. Walker place
91. Gum Mast
92. Sulter mine
93. Sholt prospect
94. Donahue prospect
95. Leckie-Moss mine
96. Chestnut Ridge prospect
- TAZEWELL COUNTY
97. Ads Ridge prospect
98. Buckhorn Mountain prospect
99. Nye Cove prospects
100. Hale property
101. Carier prospects
102. Robert Anderson place
103. Harmon prospects
104. Tiplop prospect
105. Dill mine
106. Pocahontas mine
107. J. P. Crockett place
108. Mack Jones place
109. Henry A. Bowen place
110. Laura Hurt prospect
111. Ireson and McMullen properties
112. Crabtree place
113. Charlie Jones place
114. Gose mine
115. S. W. Bowen place
116. Yost prospect
117. Peery mine
118. Higginbottom prospect
119. Claypool prospect
120. Coryell prospect
121. Short mine
- RUSSELL COUNTY
122. Whitt prospect
123. C. A. Smith place
124. Helbert mine
125. Fortner Place
- WASHINGTON COUNTY
126. Fullen prospect
- SCOTT COUNTY
127. Powuers prospect
128. Charles Perry prospect
129. Robinson prospect
- WISE COUNTY
130. Butcher Creek Hills

